ANNUAL REPORT

1955

RUBBER RESEARCH INSTITUTE OF MALAYA

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Price three dollars

ANNUAL REPORT

1955

Corrections

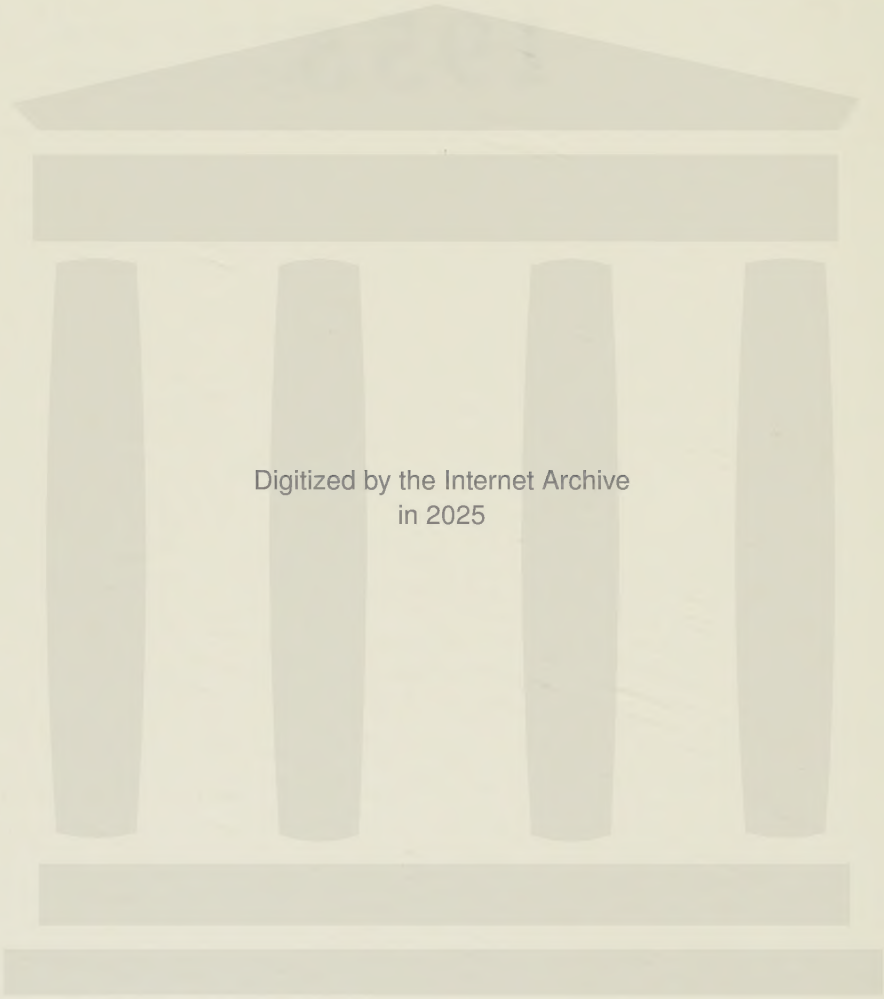
1953 Annual Report

Page	
8	*Line 30, for* **urethal** *read* **urea**
12	*Line 14, for* **fungicides** *read* **insecticides**
85	*Pathological Division for* **F.W. Hutchinson** *read* **F.W. Hutchison**
85	*Pathological Division for* **R.A. Fox B.Sc.** *read* **R.A. Fox B.Sc., B.Agr.**

1954 Annual Report

Page	
36	*In the tabular matter under the heading 'bark thickness (mm) at height of 40in.' the figures* 7.8 *and* 7.1 *should be transposed*
59	*First line, for* **1953** *read* **1954**
83	*Pathological Division for* **R.A. Fox B.Sc.** *read* **R.A. Fox B.Sc., B.Agr.**

RUBBER RESEARCH INSTITUTE OF MALAYA



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Report of the Board

The substantive membership of the Board continued as in 1954 except for the resignation of Mr D. W. Hawkins on his retirement from Malaya; Mr A. W. Goode was appointed to succeed Mr Hawkins.

During the absence on leave of the Hon'ble Mr J. C. Mathison, Mr J. W. R. Collett was appointed to serve in his place; The Hon'ble Mr C. Thornton, C.B.E. was appointed in place of The Hon'ble Mr G. M. Knocker who was on leave during the latter half of the year.

In the absence on leave of the Director, Mr C. E. T. Mann, from June until the end of the year, Mr C. G. Akhurst was appointed to act as Director and to serve as Chairman of the Board.

The Hon'ble Tuan Haji Sheikh Ahmad bin Sheikh Mustapha, C.B.E., J.P. and Mr Fong Yeok Seng were reappointed to represent Smallholders on the Board for a further period of three years from August 1955.

The Board held three statutory meetings and three special meetings; the Permanent Committee met on four occasions. An ad hoc Committee of the Board was appointed to consider revision of salary scales and other conditions of service of R.R.I. staff and met three times before presenting its report to the full Board.

The R.R.I. programme of research and estimates of expenditure for 1955, as approved by the Board in November 1954, were submitted to the Controller of Rubber and the Malayan Rubber Fund Advisory Committee. At the request of the Rubber Producers' Council of the Federation of Malaya, the Board's estimates together with those of the British Rubber Producers' Research Association and the British Rubber Development Board were submitted for coordination by the industry's advisers in London. The coordinator's report together with comments on the research programme by the Board's scientific advisers in London were received in February 1955. The programme recommended followed the Board's original plans, except for postponement of a small number of new research and technical development projects. In July 1955 the Board considered and approved a further provisional programme of work and estimates for 1956 together with skeleton plans and estimates for the years 1957-1960. Plans for 1956 were submitted to London for coordination, reported upon and accepted before the end of the year.

The estimated total expenditure of the Institute for 1955 was $4,393,700 of which $3,440,000 represented estimated expenditure on all services provided from H.Q. in Kuala Lumpur: $953,700 covered estimated expenditure on the R.R.I. Experiment Station at Sungei Buloh. The estimated revenue from the Experiment Station for the year at $740,000, derived from sales of rubber and planting material, will be exceeded.

C. E. T. Mann
Chairman of the Board

Report of the Director

The work of all Divisions of the Institute continued on the basis of the 1953 establishment, subject to absences on leave and changes of senior staff of whom during the year, ten members were away for varying periods, two research officers resigned and three research officers were appointed.

The work of the Institute falls into two main divisions; work on production of rubber as undertaken by the Botanical, Soils and Pathological Divisions, and work on the product which is undertaken by the Chemical Division.

The R.R.I. Smallholders' Advisory Service, working in cooperation with the Department of Agriculture, the Rubber Industry (Replanting) Board — 'Fund B', the Rural and Industrial Development Authority, and the Cooperative Societies Department, has continued to serve smallholders.

The Statistical Section and the Information and Publications Section have rendered assistance to all Divisions. Six numbers of the *Planters' Bulletin* were issued and five *Journal* Communications were published.

The R.R.I. Experiment Station provided for a major part of the field research programme and, through the factory and new laboratories, provided facilities for the expansion of fundamental research on latex, and the development of new products and processes.

SOILS DIVISION

Manuring of hevea—Results of experiments in replanted areas showed that, provided phosphate was applied in the planting hole, any response to post-planting treatments in the first year of growth was due mainly to nitrogen. The effect was predominantly linear and the evidence suggested that frequent applications of sulphate of ammonia may prove the most suitable treatment for most replantings on inland soils. No response to potash, or to further applications of phosphate after planting, was detected in the first year.

Phosphate applied in the planting hole had a marked beneficial effect, but there was no significant difference between superphosphate and the insoluble rock phosphates. It would appear that 4 oz of rock phosphate applied at time of planting may be adequate for normal growth of the rubber plant in the first two years. No advantage was gained by splitting this dosage into 4 lots of 1 oz or 2 lots of 2 oz applied at different times in the first year.

Records obtained during the year from manuring experiments in mature rubber areas continued to show beneficial effects due to treatment with nitrogen and phosphate in terms of both growth and yield. The magnitude of the effect on annual girth increments could be as high as 30% while the effects on yield fell within the range 5 to 20%. Trees approaching 20 years of age continued to respond to treatment with phosphate as well as nitrogen, and in some experiments the response to phosphate was greater than that due to nitrogen. A response to fertiliser treatment was established in areas on coastal alluvial soils. The effect was smaller than on inland soils and might not be economically worth while. In two experimental areas on the alluvial soils a beneficial effect on growth was observed in the fifth year after commencement of a biennial manuring programme and continued in the sixth year. No effect on yield was established with confidence although there was an indication

of an effect due to phosphate in one area. It was confirmed that treatment with magnesium-lime had a beneficial effect on growth of mature rubber trees showing symptoms of magnesium deficiency.

Cultivation and ground covers—Weed eradication work during the year was concerned mainly with testing a variety of herbicides for the control of grasses in an effort to find a suitable substitute for sodium arsenite. A new weedkiller named Dalapon showed considerable promise. It proved especially effective for the control of a variety of grasses commonly found on rubber estates. The trials indicated that grasses in young immature rubber areas could be controlled successfully by spraying with a solution of Dalapon at the rate of 10 to 15 lb of the salt per acre twice a year. Spraying treatment once a year would probably be sufficient in mature areas. No harmful effects were observed on rubber trees, following treatment of weeds in tree rows. Dalapon is the trade name for the sodium salt of 2,2-dichloropropionic acid; it is readily soluble in water and is not highly toxic to animals.

The sodium salt of trichloracetic acid (Lallicide) may also be used as a substitute for sodium arsenite for control of grasses in tree rows. Successful results were obtained with solutions containing 25 lb of the salt in 100 gallons of water; treatment with solutions of this strength had no harmful effects on the rubber trees. Experiments on the control of ground covers in young rubber areas showed that strip-weeding, or spraying combined with mulching, were the most effective methods of upkeep as judged in terms of girth increment of the trees.

Root distribution studies—The distribution of the roots of rubber trees of various ages was studied on inland and on coastal alluvial soils. The observations indicated that there was no objection to placing fertilisers in cleared spaces along tree rows if it was expedient to do so. There was no support for the suggestion that manuring could be effective only when fertilisers were placed in cleared strips, at increasing distances from the trees as they grew older, with a view to covering a zone of maximum root concentration.

Plant investigations—Investigations to compare bark analysis with leaf analysis as a means of assessing the mineral status of rubber trees were carried out, and preliminary results showed that analysis of bark samples may be satisfactory. In view of the variability in chemical composition of leaves according to age, position in the crown, and the practical difficulties of sampling, bark analyses may prove more useful than leaf analyses for the diagnosis of nutritional disorders of mature trees.

The possibility of predicting the yielding capacity of unproven clones on the basis of chemical estimation of rubber in the tissues at an early age was considered. There was a measure of agreement between the rubber concentration of petioles and the results of test tapping of different clones, but much more work must be done before the procedure can be applied for the assessment of yield potentialities.

Further observations have been made on the effects of boron and calcium deficiencies. Boron deficiency resulted in an abnormal distribution of the foliage which might be described as a 'bottle-brush' top. Calcium deficiency caused severe retardation of growth but no easily recognised characteristic leaf symptoms were produced. Calcium deficient plants contain much less oxalic acid in the stems than plants receiving other treatments.

The glasshouse, erected and put into service in 1954, proved eminently suitable for studies of micro-nutrient element deficiencies. Copper and zinc deficiency symptoms of rubber seedlings were produced in sand culture and for the first time a record is available of the appearance of rubber plants under these deficiency

conditions. While enhanced copper status appeared to decrease the concentration of rubber found in the leaves and stems, neither low zinc nor low molybdenum supplied seemed to produce a clear effect on rubber concentration. Conditions of either copper or zinc deficiency increased the nitrogen and phosphorus concentrations found in the stems and roots, but whereas a lack of copper decreased the iron concentration in the roots zinc deficiency had the opposite effect.

It was most noticeable that the leaves and growing points of zinc deficient plants became severely infected with *Oidium hevea* and the tentative conclusion was drawn that a state of zinc deficiency predisposed the plants to infection by *Oidium heveae*. It seems credible that when *Oidium* is inclined to recur in certain areas or countries that the infected plants may be zinc deficient. When supplied with ammonium-nitrogen, rubber seedlings did not exhibit symptoms of molybdenum deficiency and possessed a smaller requirement for molybdenum than if supplied with nitra-nitrogen only.

Advisory work—The number of enquiries and the nature of the problems were similar to those of previous years. Manuring of immature and young mature rubber areas was again the most important subject; there were few enquiries on manuring of old rubber. The number of requests for advice on methods of application of fertilisers increased and it was evident that more careful attention to this aspect of manuring was required.

Requests for advice on control of ground covers and elimination of weeds came next in order of frequency. Eradication of specific grass types by the use of herbicides formed the subject of many enquiries, and in spraying trials carried out during the year more attention was given to control of grasses than to eradication of other plants.

Visits to estates were made mainly to advise on manuring and on general replanting problems, and to investigate the cause of backward growth. Numerous leaf samples were analysed for diagnostic purposes. Inadequate manuring, unsuitable methods of fertiliser applications and poor drainage were the most common causes of retarded growth in young areas. Magnesium deficiency was a frequent factor and there was some evidence to indicate that potassium deficiency was not uncommon in mature rubber areas. A few small areas showing symptoms of iron deficiency were observed.

Three articles were prepared for publication in *Planters' Bulletin* and four papers on different aspects of nutrition of hevea have been submitted for publication in outside Journals.

BOTANICAL DIVISION

Breeding and selection—Nearly 1,000 new legitimate seedlings were obtained from hand pollinations representing seven different families, and some 600 new clones were made from the legitimate seedlings of the 1953-breeding programme. Eight new selections of clones under small scale trial were made and given the numbers RRIM 631 to 638. These were budded in a large scale field trial. Tapping commenced in October in the oldest large-scale trial of the RRIM 600-series clones.

Work continued on the study of disease resistant clones, seventeen *Dothidella*-resistant clones, resistant to South American leaf blight received by exchange with Brazil, were planted in a large scale field trial. Several hundred crown and branch buddings of *Dothidella*-resistant clones were made, and sufficient flowering is expected in 1956 to

permit commencement of a new breeding programme, to combine high yield and resistance to destructive leaf diseases.

Budwood of twentyfive *Dothidella*-resistant clones was despatched to Indonesia, Indochina and Ceylon during the year. Negotiations were put in hand for the importation of a further eight clones from the United States Department of Agriculture on behalf of all countries in South East Asia. Three clones likely to be resistant to the fungus were received from Indonesia.

Attempts to forecast the yield of untested clones were continued by counting latex vessels and calculating sieve tube size, by preliminary testing, and, in cooperation with the Soils Division, by determining the quantity of rubber in portions of the leaves of different clones.

Tests have continued in the Chemical Division on the latex and rubber of RRIM clones, and special observations were made on leaf fall, refoliation, flowering and seeding with a view to correlating these factors with latex properties as assessed by standard tests developed by the Chemists.

Of material under large scale variety trial, twentysix trials on fifteen estates totalling 1046 acres remained in recording. Recording of five trials on three estates totalling 232 acres was discontinued for various reasons, including labour difficulties and irregular or dubious records. Immature trials of new clones now total 34 complete trials.

Tapping experiments—Tapping experiments on full circumference systems were continued and indicated that the growth of young budded rubber is notably retarded by full circumference tapping. Introduction of resting periods showed evidence of beneficial effect on girthing but the reduction in frequency lead to a loss in yield. Two tapping experiments on planting material susceptible to brown bast are in progress where avoidance of a high brown bast incidence, without reducing the tapping intensity, has been attempted by periodical change-over of tapping cuts.

The results from a series of tapping experiments on nine standard clones have shown reliable large increases in yield for all clones under alternate daily tapping on high cuts. When high and low cuts were used on opposite sides of the trees at alternate daily intervals there was no evidence of interference between the cuts, and greatly increased yields were obtained. A new tapping-cum-manuring experiment has been laid out on a field of buddings of clone PB 86.

The original experiments on yield stimulation have been continued, and seven new experiments commenced. The decrease of response found after successive half yearly applications appears to have come to a halt. This trend has been observed in other experiments, whether application of the stimulant is above or below the tapping cut. Some evidence of a retarding effect on growth was found in an experiment on young Tjir 1 buddings, on trees of over twenty years of age no such effect has appeared. It has been confirmed that the increased rate of bark renewal caused by application of yield stimulants above or below the tapping cut is due almost entirely to proliferation of cellular tissue in the outer bark region, and not to stimulated activity of the true cambium.

Diesoline and Diesel-Fuel appeared to be satisfactory carriers of 2, 4, 5-T for tree poisoning purposes. All trees treated with a 5% solution of the synthetic growth substance were dead within six months; the most vigorous trees survived the longest.

It appears that the roots remain alive in the soil for a considerable period after the death of the bole but this is being studied more closely.

Physiology—Work on culture of hevea callus tissue continued to prove unrewarding. An up-todate review of recent research work on the biosynthesis of rubber has been prepared with a view to publication. An *Avena* coleoptile extension assay was tested for use in estimating the auxin content of hevea bark. A number of acetate nutrient experiments were inaugurated. Acetate treated seedlings showed less vigorous growth and yellower leaves. The persistence of 2, 4, 5-T in the soil was examined.

Ecology—Identification of cover plant species has continued. The method of testing seed of legumes for germination was revised. Investigations have been initiated with the object of assisting estates to produce their own cover crop seeds, and intensive search for beneficial new covers continued. A suitable unnamed species of *Clitoria* has been found, and three new species have been received in exchange with Kenya. Detailed studies of the flora of the R.R.I. Experiment Station continued.

Advisory work—The amount of advisory correspondence was nearly double that of 1954, and one-third of the queries were concerned with the choice of planting material, which clearly reflects increasing interest in replanting.

The subjects of yield stimulation, tree poisoning and tapping accounted for about equal numbers of enquiries and, together with queries on the identification of cover plants and rubber seeds, made up approximately a further third of the advisory correspondence.

Correspondence on the subject of clone exchanges and testing of new material was also heavy. Considerable interest was shown in material new to Malaya, and much of it concerned the export of planting material. Routine correspondence on the identification of clones on estates, and general enquiries completed the remainder of the advisory correspondence.

Advisory visits paid to estates trebled in number and the number of visits to R.R.I. trials by Field Assistants also increased. Apart from routine checks, the Division's clone identification mandors undertook the work of checking all Agricultural Department budwood nurseries and all seed collection areas which supply planting material for Smallholders.

Seven lectures were given to Planters' Societies. Three editorials, seven articles, two replies to letters, and three notes were published in the *Planters' Bulletin*. Three papers on 'Stimulation of Yield in Hevea Brasiliensis' were published in the R.R.I. *Journal*.

PATHOLOGICAL DIVISION

Root disease—In a root disease experiment on an inland soil, where the old trees were removed for firewood, the effect of stump poisoning has been to reduce the incidence of disease in the young stand by sixty per cent over the first five years, during which time routine control has been carried out. On a coastal site where the old stand was felled and left on the site the reduction in disease incidence resulting from stump poisoning has been only thirty per cent over four years, whereas tree poisoning reduced the incidence by eighty per cent. The smaller effect of stump poisoning in the latter experiment may be due to the effect of surface timber favouring the spread of the disease, in this case almost entirely white root disease. This, the

principal root disease of rubber, is being made the subject of a detailed fundamental investigation to provide facts about the fungus and its relationship with its host. Field studies have shown that spores of the fungus can, under experimental conditions, attack rubber stumps through the cut surface. Information is also being collected on the susceptibility of jungle trees to infection by artificial inoculation.

Pink disease—has become more prevalent in recent years with the increase in the area of immature rubber which is more susceptible to attack than older trees. The study is chiefly concerned with the course of infection and the subsequent spread of the disease.

Termites—The chlorinated hydrocarbon insecticides that are effective in controlling termites have been found to persist well in all soils except peat.

Inoculation of legumes—Tests have been made with a view to preparing a packaged compost containing active *Rhizobium* bacteria for legume cover crop seed inoculation. The method has been found to be satisfactory in practice and is capable of giving results as satisfactory as with the agar cultures distributed at present for this purpose.

Pollination—A further collection has been made of insects visiting hevea flowers, mostly midges and thrips, which are believed to be largely responsible for pollination.

Aerial spraying trials with defoliants carried out to determine the procedure to be adopted for an eradication campaign against a chance introduction of South American leaf blight, have been completed.

Advisory services—Advisory correspondence on the subject of mouldy rot has fallen away so markedly over the last three years that the disease would appear to be well under control on estates. Enquiries about root, branch and leaf disease continue, and many specimens are received showing evidence of accidental poisoning by sodium arsenite, which is readily confirmed by a sensitive laboratory test. A terminal dieback of branches, exhibited mostly by clones Gl 1 under drought conditions, has again been observed in several areas in the north-west of the country.

Reports of secondary leaf fall received in response to the circular sent out each year were less than half the usual number. It appeared that *Oidium* attack had generally been relatively light.

The continuing steep rise in the demand for *Rhizobium* cultures for inoculating seed of legume covers has led to the investigation of more convenient methods of preparation and packaging.

Research Officers gave three lectures to Planting Associations.

CHEMICAL DIVISION

Research—One of the outstanding features of Chemical Division work during the year has been the application of earlier microbiological studies to the production of latex concentrate. Previous work had demonstrated the value of the VFA test for control of latex quality and the test still remains the most valuable rapid guide we have for this purpose. A much more accurate assessment, however, is given by counts of the living bacteria present, but the test usually takes two to four days to complete. Investigations at a number of factories have shown the surprisingly unhygienic conditions under which much concentrate is produced. By scrupulous attention to cleanliness, however, a remarkable reduction in the number of bacteria present in the final product have been made in every case examined. Whilst the effect of individual bacterial strains upon latex quality is by no means fully under-

stood, there is no question that proliferation of certain types of bacteria in latex caused marked deterioration in quality. The production of more sterile latices is obviously a step in the right direction, and will repay the care taken by improvement in quality.

Another aspect of our microbiological studies is the development of new preservative systems for latex concentrate; patent application has been made in respect of three new preservative combinations employing antibiotics, sulpha drugs and boric acid respectively, with low concentrations of ammonia. Attention is also being given to physical means of sterilising latex, such as the use of ultrasonic sound waves and irradiation by ultraviolet light.

Research investigations have been continued along already established lines and include studies of the enzymes present in latex, seasonal and storage changes in the non-rubber constituents of latex, the mechanism of latex coagulation, drying of coagulum, and studies of the molecular character of the rubber hydrocarbon.

In the field of special and modified rubbers much interest has been shown by consumers in superior processing crepe which has been developed at the R.R.I. during the last few years. Over twenty tons of this material were produced to satisfy manufacturers' requests and commercial production was started by one company towards the close of the year.

Four companies have continued commercial production of cyclised rubber, but according to the samples received for test, the total volume produced has been only some eighty tons. A few tons of purified crepe have been supplied to users in Great Britain in response to requests for material containing a reduced amount of non-rubber substances and for rubber showing low water absorption; manufacturer's evaluation is awaited.

Rubber-lignin masterbatches are being produced on a pilot-plant scale, and it has now been demonstrated that graft polymers using natural rubber can be satisfactorily prepared under Malayan conditions.

Advisory work—The Chemical Division Advisory Service to producers has been maintained throughout the year although the volume of work carried out was somewhat less than in 1954, owing to staff vacancies and incidence of leave. Enquiries received chiefly concerned the production of latex concentrate, considerable interest being shown in latex quality as mentioned above and in accurate methods for determining dry rubber content. Enquiries concerning smoked sheet rubber were concerned largely with methods of avoiding defects which result in the down-grading of RSS. Interest in pale crepe rubber fell off considerably during the early part of the year but revived during the last two months.

The R.R.I. testing station for technical classification of rubber has continued in operation, an average of 115 estates submitting their production for classification. Samples tested represent about 32,000 tons of which 29,000 tons were RSS 1. Nearly 2,000 tons of air dried sheet were also classified. Packing houses and remillers have shown less interest in classification, samples tested representing approximately 3,000 and 550 tons respectively from these two sources. Consumers' demands appear to have been for 'yellow' class rubber, little interest being shown in 'red' rubber. It is fortunate that the conversion of 'red' into 'yellow' rubber is a comparatively simple matter for estates; a number of factories are now employing the R.R.I. method to convert all their crop to 'yellow' rubber.

The R.R.I. has continued to act as coordinating Institute for the technical aspects of the T.C.R. scheme under the aegis of the International Rubber Research Board. Other Institutes have shown much interest in extending technical classification to cover cleanliness as well as vulcanising characteristics. A survey of the R.M.A. types produced in Malaya in respect of dirt content is in hand; results already indicate marked differences between the types as well as considerable variation within certain types.

SMALLHOLDERS' ADVISORY SERVICE

Replanting and new planting—Either replanting or new planting may be the dominant feature of the work of a Rubber Instructor depending on the location of his district. In replanting, demonstration of the use of 2, 4, 5-T in diesel oil was an important task, following the distribution of this material by the replanting scheme, and records were maintained on the action of the poison and the rate of decay of trees on selected holdings. Observations by Rubber Instructors on replantings established during the last few years serve to confirm fears that root disease may become a very serious problem in the replanting of smallholdings. The method of felling trees by sawing through the bole without removing the roots or poisoning them provide conditions for increase of root disease.

Rubber Instructors have recorded the planting of rubber by smallholders on approximately eight thousand acres of new land, the largest areas planted are in the states of Pahang and Perak. It is expected that there will in future be increased development of new areas in Kedah, Kelantan and Trengganu and improvement of the staff position in these states has been attempted. In view of the shortage of supplies of clonal seeds within Kelantan and Trengganu special emphasis has been placed on the technique of budgrafting in these States.

Production—Some postwar plantings are now reaching tappable size and Rubber Instructors have been giving attention to the opening up and tapping of such areas. Where possible, yield figures are being recorded.

Processing—The collection of smallholders' latex at central points remained firmly established as a method of disposal of crop in those areas which had adopted the method in previous years. No important extension of the system was noted but in the second half of the year, with the general reduction in the demand for latex for concentration, more sheet rubber was manufactured in centralised processing stations to compensate for the decline in sales of latex. It is estimated, that over 5,000 tons of smallholders' rubber were handled in central collecting and processing centres during the year.

Information has been sought on the part played by central processing factories in production of sheet from Chinese smallholdings. These are well equipped factories to which tappers bring their latex to make sheet rubber themselves. The sheets, marked with a stencil plate for each individual smallholder, are smoked and stored on behalf of the owner who withdraws smoked sheet for sale when he wishes. Such factories are run efficiently by enterprising persons who make a fixed charge per picul of rubber for the use of equipment, smoking and storage facilities. The quantity of rubber processed by this system is not less than the amount collected as latex and the quality of the smoked sheet is well above the average produced on smallholdings.

Information—Training for replanting scheme staff was combined with the course for probationer Junior Rubber Instructors which extended from February to the end of April. Courses for smallholders were provided wherever a demand was established

and suitable facilities could be secured. Two courses for smallholders were held at the Experiment Station and a total of seventyseven young men attended.

Exhibits prepared for state and district agricultural shows dealt with planting material and particularly with the technique of budgrafting. Smallholders films were shown at the R.R.I. stand at the Malayan Agri-Horticultural Exhibition and Rubber Instructors were on duty throughout the show to explain details of the R.R.I. exhibit to smallholders. It is however regrettable that the result of considerable expenditure of time and money on this annual event is viewed by only a handful of smallholders, the mass of viewers being urban with little appreciation for details of agricultural exhibits.

The English edition of the booklet, 'Replanting on Smallholdings' was received from the printers in October and the Chinese and Malay editions will be available early in 1956. Reprinting of booklets on 'Root Disease Control in Young Rubber' and 'Budgrafting' was undertaken.

STATISTICS SECTION

Mr D. K. D. Rav, assistant statistician, resigned on 14 June, and his successor, Mr G. C. Iyer, joined the Section on 20 August. The statistician (Mr D. R. Westgarth) and three computers were on duty throughout the year. Two articles were prepared for the *Planters' Bulletin*.

Investigations—Altogether some 30 designs for new field or laboratory experiments were prepared and about 120 reports dealing with the statistical analysis of Divisional experiments were completed. The practical results of this statistical work are embodied in the appropriate Divisional reports and we refer here only to those new topics which are of interest in terms of their statistical method.

Several estate trials of the new series of 100 Exchange Clones from Java, Sumatra, Indo-China, Ceylon and Malaya have been planned in collaboration with the Botanical Division. A feature of the designs, which are all simple lattices, is that each estate trial contains the complete series of 100 clones, but each clone is only replicated twice. Plot size, which is partly governed by the need to avoid competition effects, has been retained at the usual 0.4 acre. The acreages available and the need to accommodate the complete series on each trial site has dictated the use of only two replications. Hitherto in estate trials, four or five replicates have been employed with balanced incomplete block designs, so that varietal comparisons were relatively precise for a particular site. However, this tended to restrict the number of clones per site to some fraction of a complete series and difficulties arose when attempting to consolidate the results of several trials because varietal comparisons were confounded with site differences. The technique of maintaining a control clone common to every trial does not provide a completely satisfactory answer to this problem of eradicating site differences because of the existence of interaction between sites and varieties. The present approach should result in a much more satisfactory consolidation of the results of several trials; individual estate trials will be less precise but each will test a correspondingly wider selection of material.

Recent studies of the experimental errors in the measurement of various technological properties of rubber have emphasised the need for an improved statistical technique for estimating the relative sensitivity of different technological tests. The relative ability of two correlated tests to discriminate between different rubbers can be expressed in terms of a sensitivity ratio. Approximate tests of significance have been

developed for these ratios but certain aspects of this sensitivity problem still require further study.

Useful economies in certain laboratory experiments and one field trial have been effected by the use of fractionally replicated designs. Although such experiments do not contain a single complete replication of all the possible treatment combinations, they do permit conclusions about the main treatments effects or their more important interactions. Arising from this use of fractional replication, a study was made of various approaches to the problem of tests of significance in analysis of variance tables containing no 'a priori' error term.

Advisory work—Visits were paid to 12 estates in connection with field trials, and requests for statistical advice were received from 12 officers of other research organisations.

R.R.I. EXPERIMENT STATION

The Acreage statement as at 31 December 1955 was:			Acres
Mature rubber	In tapping		1,142.00
	Resting		10.00
Immature rubber:	New planting		606.00
	Mature in tapping		55.75
	Nurseries		24.50
New clearing			281.50
Smallholders' nursery & seed garden:			202.00
	Mature in tapping	10.25	
	Immature	191.75	
Building site and roads			7.25
Reserve land			547.00
		Total	2,956.00

New clearing—Reserve land 281.5 acres, was cleared of jungle and planted mainly with germinated seed; in 60 acres of low-lying land seedling stumps were used.

Immature area—Normal maintenance and upkeep was continued over nearly 700 acres of immature rubber, of which some 260 acres received fertilisers.

Budgrafting was carried out over 70 acres of the 1954 new clearing.

Quarterly slashing rounds on bush covers were carried out, and in the youngest areas strip spraying with sodium arsenite was used in the second half year. In certain fields only grasses are kept out of the planting rows after the first twelve months following budding.

Mature area—The total mature area in tapping amounted to 1142 acres, and the total crop obtained was 1,083,850 lb, about three quarters of which was manufactured as latex concentrate.

Planting material—The Smallholders Nursery Reserve of nearly 200 acres which has been established for seed production, received a fertiliser application. No seed has yet been harvested. Budwood from this nursery amounting to 55,500 yards was despatched to smallholders. From the Experiment Station nurseries, 11,500 yards of budwood were despatched to estates.

General—Training courses were held at the Station during the year for various categories of workers, including Senior Estate Conductors, existing and prospective Rubber Instructors, Replanting Board subordinate staff and kampong youths.

No mention is made of experiments in progress for these are reported upon by the Divisions concerned.

C. E. T. Mann
Director

Soils Division

The Head of Division and the Soils Chemist (Mr G. M. F. Grundy) were on duty throughout the year. The Plant Physiologist (Dr E. W. Bolle-Jones) was on home leave from April to November. The Research Staff was strengthened by three new appointments during the year: Mr V. R. Mallikarjuneswara assumed duty in April as Assistant Chemist to work on problems relating to nutrition of rubber, Mr M. M. Guha joined the staff as Assistant Soils Chemist in May and Dr G. A. Watson was appointed as Soils Chemist and reported for duty in November.

Two papers on subjects relating to nutrition of hevea, written by the Plant Physiologist, were published during the year. *1* 'Tentative Method of Sugar Estimation in Laminae and its Application to *Hevea brasiliensis*'. *2* 'Comparative Effects of Ammonium and Nitrate Ions on the Growth and Composition of *Hevea brasiliensis*'. Another paper entitled 'Molybdenum Status of Laminae as Determined by Bioassay and Chemical Methods' was prepared for publication in *Plant and Soil* and a note on 'Zinc Deficiency of *Hevea brasiliensis* as a Predisposing Factor to Oidium Infection' was submitted for publication in *Nature*.

As part of the training scheme for Smallholders' Rubber Instructors, held at the Experiment Station, the Soils Chemist (Mr Grundy) gave a course of lectures on soil topics. He also gave lectures on soils and related topics to groups of estate Conductors attending courses of instruction at the Experiment Station. The Head of Division gave a lecture to members of the Central Johore Branch of the Incorporated Society of Planters at Rengam.

The usual assistance was given to the Technical Education Scheme of the Incorporated Society of Planters by setting questions and marking papers for the soils section of the Agricultural Science examinations held in February and August.

RESEARCH

MANURING OF HEVEA

Manuring experiments in progress include 36 in mature and 6 in immature rubber areas, all sited on estates in different parts of the country. In addition to these there are 3 experiments in mature and 3 in immature areas at the R.R.I. Experiment Station. Growth measurements were recorded in all experiments and yield records were obtained from 37 out of the 39 experiments in mature rubber areas.

Effect of fertilisers on growth—Results obtained during the year in an experimental area replanted in 1954 showed that, provided phosphate was applied in the planting hole, the response to post-planting treatments in the first year of growth was due mainly to nitrogen. The effect was predominantly linear so it is possible that applications of sulphate of ammonia at more frequent intervals than once every three months (maximum frequency in the experiment) would have had an even greater effect. No response to potash, or to further applications of phosphate after planting, was detected in the first year.

This conclusion relating to the absence of response to additions of phosphate over and above the application in the planting hole at the time of planting was supported by results from another experiment which has been in progress for three years. Growth measurements recorded during the third year after planting show no further response to continued applications of phosphate at different intervals. No significant difference was established, in terms of effect on growth, between superphosphate and the insoluble Christmas Island rock phosphate nor was there any difference between the broadcast and the 'pocket' methods of application. In regard to phosphate manuring during the earlier stages of growth it would appear that 4 oz of either concentrated superphosphate or Christmas Island rock phosphate mixed with the soil in the planting hole at time of planting may be adequate for normal growth in the first three years in replantings on the heavier inland soils. No advantage was gained by splitting this dosage into 4 lots of 1 oz or 2 lots of 2 oz applied at different times in the first year.

Judged on observations made at 9 months after planting, 8 oz Sterameal planting hole mixture was slightly more effective than 4 oz Christmas Island rock phosphate as planting hole treatment. However, the difference in mean height of plants was small, amounting to only 3.4 inches at 9 months.

In regard to the effect of fertilisers on growth of mature trees, results confirm earlier conclusions as reported in previous reports. The trend of effects as revealed by analysis of collective data from two groups of experiments was discussed in the annual *Report* for 1954. Data from a third group of experiments (factorial 3 x 3 x 3) have since been analysed and they show the same pattern of effects. It is firmly established that manuring with nitrogen and phosphate has had a beneficial effect on growth.

More recent data from individual experiments have also been analysed; these data were obtained from areas where the trees are approaching 20 years of age. A beneficial effect due to nitrogen was established in 9 out of 29 experiments examined and there were indications of a similar effect in 4 others. A response to phosphate was proven in 7 experiments and in one of these the magnitude of the effect on annual girth increment was as high as 30%. An improvement in girth due to applications of potash was detected in only 2 experiments.

In previous reports it has been stated that in experiments sited in coastal alluvial clay soils there was no evidence of any effect due to manuring. More recent results from experiments in mature areas on these heavy soils show a beneficial response to nitrogen in one, and to phosphate in another. The effects developed in the fifth year after commencement of a biennial manuring programme and continued in the sixth year.

Effect of fertilisers on yields—As with growth records, analysis of further yield data during the year confirm earlier conclusions as reported in the annual *Report* for 1954. Yield records from the factorial 3 x 3 x 3 group of experiments have been examined and the pattern of responses is similar to that shown by results from the other groups. The conclusions derived from a study of the combined data from the three groups of experiments support the observation that a beneficial effect due to nitrogen develops first in the presence of potash while later on the effect of potassium on nitrogen response diminishes. The main effect finally is due to nitrogen, or phosphate, or both of these nutrient elements.

When annual yields from individual experiments are analysed separately it is less easy to detect responses to fertiliser treatments probably because of lack of precision

when recording yields on some estates. Results from two experiments showed a beneficial effect due to nitrogen judged on yield records on 6 days during the year and in two other experiments there was a marked response to phosphate. One of the experiments where a beneficial effect on yield due to treatment with phosphate has been clearly demonstrated is sited at the Experiment Station where accurate recording of yields under strict supervision is possible. This area was planted from jungle in 1935 and budded in 1937. Fertilisers have been applied every second year since 1947. A beneficial effect due to treatment with phosphate was firmly established in the fourth year after commencement of the manuring programme and this effect has persisted ever since. There are five different clones in this experiment and, as is to be expected, yield levels vary widely but it is of interest to note that all five clones respond to fertiliser treatment in the same way *i.e.* no clone x treatment interaction has been demonstrated. This evidence indicating that different clones show a similar response to fertiliser treatment is supported by results from other experiments where there are two or more clones.

Effect of fertilisers on seed production—Results of seed count made once during the year in a few manuring experiments support earlier conclusions as reported in the annual *Report* for 1954. There were strong indications of increasing seedfall with increasing levels of nitrogen and phosphorus, whereas applications of potassium appeared to have the opposite effect. In one experiment there was also a significant reduction in seed count associated with the higher of two levels of application of magnesium lime.

CULTIVATION AND GROUND COVER

Weed eradication—Weed eradication work during the year was concerned mainly with testing a variety of herbicides for the control of grasses in an effort to find a suitable substitute for sodium arsenite.

Tests with Maleic hydrazide showed that treatment with a solution containing 10 or more pounds of MH in 100 gallons of water did inhibit growth of smaller grasses such as *Axonopus compressus* and *Paspalum conjugatum* for a short period, but the effect was not sufficiently marked to make it worth while using this chemical for control of grasses in rubber areas. The effect on new growth of the larger grass *Imperata cylindrica* (after slashing and clearing the dense older growth) was barely noticeable.

A new weedkiller named Dalapon offered considerable promise for use in rubber areas. It proved unusually effective for the control of a variety of grasses commonly found on rubber estates including *Axonopus compressus, Hemigymnia fusca, Cyrtococcum accrescens* and *Panicum sarmentosum*. Rates of application in the range 10 to 50 lb per acre were tested. The mean maximum effect was estimated to be 90% kill in the plots sprayed at the rate of 10 lb per acre and 100% in the others. With the lowest rate of application there was no noticeable recovery until about 4 months after treatment and about 7 months with applications of 15 lb per acre.

For control of grasses, Dalapon was more effective than sodium arsenite, sodium chlorate, sodium trichloroacetate and Shell Lalang Oil. The tests indicated that grasses in young immature rubber areas could be controlled successfully by spraying with a solution of Dalapon at the rate of 10 to 15 lb per acre twice a year. Spraying treatment once a year would probably be sufficient in mature areas. No harmful effects on rubber trees, following treatment of weeds in tree rows, were observed.

Dalapon is the trade name for the sodium salt of 2,2-dichloropropionic acid. It is readily soluble in water and is not highly toxic to animals.

The sodium salt of trichloroacetic acid (S.T.C.A.) may also be used as a substitute for sodium arsenite for control of grasses in tree rows. Good results were obtained by spraying at the rate of 25 lb of the salt in 100 gallons of water per acre. Applications at this level along tree rows had no noticeable harmful effects on young rubber trees. Compared with Dalapon, S.T.C.A. acts more slowly and rate of recovery of grasses after treatment is quicker, but both are more effective than either sodium arsenite or sodium chlorate. Judged in terms of recovery rate the addition of sodium pentachlorophenate did not improve the effect of either Dalapon or S.T.C.A.

Comparison was made between sodium arsenite, S.T.C.A. and Dalapon in trials for control of lalang (*Imperata cylindrica*). Rates of application were: sodium arsenite 15 lb, S.T.C.A. 25 and 50 lb, Dalapon 20, 40, 60 and 80 lb per acre. With the lowest rate of application of Dalapon the percentage kill was estimated to be 65% but the lalang regenerated rapidly after two months. The mean maximum effect and the time interval before recovery increased with increasing rates of application. With 80 lb per acre, the percentage kill was estimated to be 85% and there was very little new growth up to five months after treatment.

When lalang was slashed before spraying, smaller quantities of Dalapon were effective in inhibiting new growth for several months. Application at the rate of 20 lb per acre was only slightly less effective than 40 and 60 lb per acre.

When sodium arsenite was used aerial growth was completely killed within a day or two but there was abundant new growth after a week or ten days. It is known that for effective control of lalang with sodium arsenite several rounds of spraying at fairly frequent intervals would be necessary. With Dalapon, the effect became noticeable more gradually but lasted much longer than with sodium arsenite. In this respect the effect of Dalapon was similar to that of S.T.C.A. but the former was more effective in that smaller quantities were required to produce the same results.

Control of ground cover and mulching—Further observations made in small scale trials during the year supported earlier evidence indicating that strip weeding of tree rows combined with mulching is the most effective method of upkeep in young rubber areas judged in terms of girth increment of the trees.

Cultivation—In a replanting where the ground had previously been prepared by cultivation (ploughing and harrowing) by mechanised equipment the advantage gained by holing, as opposed to planting without holing, amounted to a mean increase of only 2.8 inches in height of the rubber plants at 9 months after planting.

Records obtained in the fifth year after commencement of treatments again showed that cultivation of the soil between tree rows once a year by disc ploughing and/or disc harrowing had neither a harmful nor beneficial effect judged in terms of growth and yield of the trees. It is to be noted however, that the soil in this experimental area is a light sandy loam. The trees were eighteen years old when the experiment started and it is of interest to note that severance of surface roots once a year by cultivation implements has not so far produced any detectable harmful effect on the trees.

SOIL INVESTIGATIONS

Soil temperature—A brief study was made of soil temperature fluctuations at varying depths in covered and uncovered soils. Differences between maximum temperatures of exposed soils and those under the different types of ground covers varied from 12 to 30°C at the surface, 2 to 10°C at 4½ inches and 2 to 8°C at 9 inches below the surface. Ground covers included in the comparison were grass, *Mikania scandens*, *Flemingia congesta* and *Pueraria phaseoloides*. Grass was the least, and *Pueraria phaseoloides* the most, effective ground cover for keeping the soil cool.

Estimation of cation exchange capacity—Six methods of determining cation exchange capacity of soils were tested and compared, using samples of local soils. Cornfield's rapid copper acetate method was found to be unsuitable while the method described by BONNET et alii (*J. Agric. Univ. P. R.* 35(1951)49) in which the soil is shaken with normal calcium chloride solution and the absorbed calcium extracted by leaching with ammonium acetate also gave consistently low results. The barium acetate method and three methods involving leaching with ammonium acetate gave comparable results, but all except one are tedious and time consuming. It was confirmed that a modification of Mackenzie's rapid micro method was suitable for routine use in the laboratory.

Values for cation exchange capacity of a variety of local soils examined range from 4 to 23 m.eq. per 100 gm of soil. Values for total exchangeable cations in the same soils vary from 0.2 to 2.5 m.eq. per 100 gm.

Root studies—It is commonly believed by members of the rubber planting community that the maximum concentration of feeding roots occurs near the root extremities. It was felt that it was desirable to obtain factual information on this subject and attempts were made to study the horizontal distribution of rubber roots of trees of varying ages. In inland soil areas, from 60 to 75% of the roots were concentrated in the top six inches of soil while in coastal alluvial clay soils no such marked concentration close to the surface was found.

With normal planting distances, uniformity in the distribution of feeding roots between tree rows was achieved when the trees were about 5 years old. There was some evidence that subsequent development led to a slight increase in root concentration in the mid-region between rows, but the difference between density of feeding roots at the centre and that at points close to the trees was never large.

The practical significance of the results is that there is no valid objection to placing fertilisers in the cleared space along tree rows if it is expedient to do so, even when the trees have reached maturity; this would depend on the density and composition of the ground cover in the inter-row spaces. The suggestion that manuring would be effective only when fertilisers are placed in cleared strips at increasing distances from the trees as they grow older, with a view to covering a zone of maximum root concentration, was not supported.

PLANT INVESTIGATIONS

Methods and techniques—Satisfactory chemical methods of estimating each of the major – and micro-nutrient elements in plant tissues were put into operation for both research and advisory purposes. The *Aspergillus niger* bioassay estimation of molybdenum and zinc was restricted to the detection of contamination of water supplies used for pot culture work. In regard to plant analysis, it was found that interpretation of results of the bioassay method sometimes disagreed with that based on chemical analysis.

Diagnosis of mineral status of hevea—Leaf and bark samples taken from trees in two field manuring experiments were examined. The result of fertiliser treatment, in terms of increased girth or yield of rubber showed as good a correlation with the concentration of the effective nutrient (phosphorus) found in the bark as with that found in the leaves. These preliminary results suggest that bark analysis may be a suitable means of diagnosis of mineral status and may be preferable to leaf analysis, particularly for mature trees, in view of the variability in chemical composition of leaves according to age, position in the crown, and the practical difficulties of sampling the foliage. This investigation will be continued.

Relationship between petiolar rubber concentration and yield—The possibility of predicting the yielding capacity of unproven clones on the basis of chemical estimation of rubber in the tissues was considered. The rubber concentration in petiole samples from young trees of some of the RRIM 600 series clones was compared with the results of test tapping carried out on the same trees. There was some measure of agreement between the results, but much more work must be done before it can be accepted that estimation of rubber concentration in petioles gives a reliable assessment of yield potentialities.

POT-SAND-CULTURE EXPERIMENT

Technique—Further improvements in experimental methods were made during the year. The sand sifting process was almost completely mechanised; this resulted in a higher standard of efficiency and a better uniformity of particle size of different batches of sand used in the experiments. The plant house, erected and put into service in 1954, was in continued use throughout 1955 and has proved eminently suitable for studies of micronutrient element deficiency under tropical conditions. Efficient methods of preparation of nutrients free of copper, zinc and molybdenum were put into operation and a new procedure was developed for the elimination of cobalt from nutrient salts.

Survey of nutrient deficiency symptoms—Continuing the experiment described in the annual *Report* for 1954, further observations were made on the effect of sulphur, boron and calcium deficiencies. Boron deficiency resulted in a characteristic distribution of the foliage which may be described as a 'bottle-brush' top. Calcium deficiency, although drastically restricting growth and even caused death of the plant, did not produce easily recognisable characteristic leaf symptoms.

Anatomical examination of the stem of the nutrient deficient plants, done in the Botanical Division, revealed the absence of stone cells and of any lignification of cell walls between the cambium and the sclerenchyma ring — unlike the condition observed in 'dry' trees. Heavy depositions of calcium oxalate crystals were observed in the pith, soft bast and outer bark layers of the stem of boron and iron – deficient plants. Marked necrosis of the pith cells occurred in the boron deficient plants.

Calcium deficient plants contained much less oxalic acid in the stem than plants of other treatments; this finding may find application as a means of identifying calcium deficiency when visual symptoms have not been recognised with certainty.

Under conditions of potassium and manganese deficiencies there was a marked accumulation of free amino-acid constituents in the leaves whereas nitrogen deficiency had the opposite effect.

Copper experiment—In the copper deficiency experiment copper was supplied at four different levels as follows: nil, very low, normal and very high. At zero level, severe symptoms of deficiency appeared when the plants were five months old;

marked dieback of the shoots occurred followed by proliferation of new shoots. Plants supplied with copper at the 'very low' level showed similar symptoms later, but much less severe. Optimum growth was obtained with the third level of supply but judging from the small difference between the Cu_3 and Cu_4 plants it would appear that the rubber plant is fairly tolerant to a high level of copper supply. Differences in the concentration of copper, according to level of copper supply, were more marked in the roots than in the shoots.

The rubber content per plant was much lower in the plants receiving no copper than in the others (severe growth retardation and therefore smaller plants) but otherwise the concentration of rubber in the laminae, petioles and stems generally decreased as the copper level increased.

Other effects recorded were that increased copper supply (*a*) was associated with increased potassium concentration in the roots but not in the lamina, (*b*) caused accumulation of iron in the roots and a depletion of iron concentration in the stem, (*c*) depressed the concentration of phosphorus and manganese in all tissues and (*d*) decreased the concentration of nitrogen in the stems and in the roots.

Zinc deficiency experiment—The effect of zinc deficiency on growth and composition of Tjir 1 seedlings was investigated. Severe symptoms of the deficiency became apparent within four months after sowing, manifested by very stunted growth with small, narrow, strap-like leaves showing a mild interveinal chlorosis. Differences between concentrations of zinc in the 'complete' nutrient plants and those in the zinc deficient plants were more marked in the stems and petioles than in the laminae. Lack of zinc was associated with increased concentrations of nitrogen, phosphorus and iron in the stems, petioles and roots.

No clear relationship between zinc supply and the concentration of rubber was found.

It is of interest to note that the leaves and growing points of zinc deficient plants became severely infected with *Oidium heveae*. While it is true that plants supplied with zinc showed occasional fungal colonies on the laminae, the intensity and severity of the attack were much less marked than on zinc deficient plants. It thus appeared that a state of zinc deficiency may be a predisposing factor, making the plants more susceptible to severe infection by the mildew. Lack of available zinc is not expected to occur frequently in the highly acid soils of Malaya but it seems credible that when *Oidium heveae* is inclined to recur in certain areas or countries that the infected plants may be zinc deficient.

Molybdenum deficiency experiment—An experiment designed to study the effect of molybdenum deficiency on growth and composition of Tjir 1 seedlings under conditions of all nitrate-nitrogen or part ammonium-, part nitrate-, nitrogen supply was started in January. Up to the end of the year, no symptoms which could be ascribed to molybdenum deficiency were observed in plants supplied with ammonium nitrogen, although growth and yield of dry matter were less than those of the 'complete' nutrient plants. Unfortunately, the 'complete' nutrient (nitrate) plants showed symptoms similar (but much less severe) to those seen in the minus molybdenum plants. The former were, however, slightly bigger and more vigorous than the latter, but apparently the absence of ammonium-nitrogen allowed the inception of interfering iron deficiency symptoms.

The concentration of molybdenum found in the tissues of the 'complete' nutrient (ammonium) plants was lower than in the corresponding nitrate plants except for the roots in which the reverse was found to be the case.

No consistent relationship was established between the concentration of rubber in the tissues of the plants and the level of molybdenum supply.

Other experiments—An experiment designed to study the interrelationships of molybdenum, sulphur and calcium in the nutrition of hevea was commenced during the year and is being continued. Results obtained to date show that increased sulphate supply markedly diminished the molybdenum concentration of the laminae. Very high concentrations of molybdenum accumulated in the laminae of the high molybdenum – low sulphate plants (six months old).

Another experiment designed to study further the relationship between the nitrogen status of the rubber plant and the severity of attack by *Helminthosporium heveae* (bird's eye spot disease) was commenced during the year and is being continued.

ADVISORY

The number of enquiries and the nature of the problems dealt with were much the same as in previous years. The statistics relating to advisory correspondence, visits and interviews may be summarised as follows:

Letters and reports despatched	336
Visits to estates	71
Interviews at the Institute	103

Manuring

Manuring of immature and young mature rubber was again the most important subject dealt with in advisory correspondence amounting to 42% of the enquiries answered. Requests for advice on manuring of old unselected seedling rubber trees were reduced to a mere trickle while the number of enquiries on methods of application of fertilisers increased considerably during the year. Judging from observations made in the field and from discussions with planters it was evident that more careful attention to this aspect of manuring was required, especially in young rubber areas. An article on methods of application of fertilisers was prepared for publication in *Planters' Bulletin*.

Ground Cover

Advice on weed eradication accounted for 15% of the advisory letters despatched. Eradication of specific grass types by the use of herbicides formed the subject of many enquiries and, in spraying trials carried out during the year, more attention was given to control of grasses than to eradication of other indigenous growths. Control of lalang (*Imperata cylindrica*) is no longer a serious problem on the larger estates Most rubber areas which were in a bad condition after the war, owing to heavy invasion by uncontrolled indigenous growths including lalang, have since been rehabilitated. Furthermore, it is now generally accepted that the cheap method of upkeep which found favour in the immediate post-war period was false economy. The normal method of upkeep nowadays is such that lalang is not allowed to become established to the extent that its control by spraying with herbicides is often neces-

sary. Sporadic growth of this weed is usually checked immediately, usually by wiping with oil. Moreover, the technique of eradicating heavy growth of lalang by spraying with sodium arsenite or other suitable herbicides, followed by wiping with oil is thoroughly familiar to most planters.

Eradication or control of the smaller grasses, on the other hand, is a constant problem. Weeding is the most expensive item in the cost of bringing a planted area into bearing, particularly during the earlier stages of growth of the rubber trees. Grasses are the most persistent weeds and control of these continuously, year after year, is necessary.

Sodium arsenite is the weedkiller that is still used most frequently for control of grasses on estates mainly because it is much cheaper than other suitable herbicides. Sodium chlorate has been used on a limited scale, chiefly in water catchment areas; it is also preferred for control of *Ischaemum muticum* as it has proved to be more effective than sodium arsenite for eradication of this particular grass species. It has been reported that this grass can be eradicated successfully by spraying twice with a solution containing 25 lb sodium chlorate in 100 gallons of water per acre. The use of oils for weed control is largely restricted to eradication of sporadic growth of lalang. Results from recent spraying trials have shown that Dalapon is much more effective than sodium arsenite or sodium chlorate for control of all smaller grasses, but until the price of this new weedkiller is considerably reduced it is unlikely that it will be used extensively for routine control of grasses on estates.

There were very few enquiries on methods and degree of control of acceptable ground covers such as leguminous creepers. For control of upright indigenous growths two models of the Holt Weedbreaker supplied by the courtesy of Holt Weed Breaker Company, Kirbymoorside, York were tried out at the Experiment Station. The two implements, the Mark VI 3-gang model and the Mark VIII B model, a single roller with blades, have been used in a small way for controlling indigenous scrub covers, chiefly *Eupatorium odoratum* (Siam weed). The heavy implements, drawn by a wheeled tractor, crush and cut the ground cover in much the same way as the Kedah roller does, but the Holt Weedbreakers have a distinct advantage in that they have a hydraulic mounting attachment. The softer upright growths such as Siam weed and Straits rhododendron (*Melastoma polyanthum*) were cut up quite efficiently but some of the more woody shrubs were only bent and bruised. It would seem however, that machines of this type could be used with advantage for control of most of the less desirable upright indigenous growths. A possible development which must be considered is that conditions might be made more favourable for invasion by grasses, which are even less desirable.

Examination and Analysis of Samples

Reports on examination or analysis of samples accounted for 15% of the advisory letters despatched. More than half the reports referred to leaf samples analysed for diagnostic purposes. Other samples received for examination or analysis included soils, fertilisers and weedkillers.

Visits to Estates

As in previous years, visits to estates were made mainly to advise on manuring, on general replanting problems, and to investigate the cause of backward growth. Inadequate manuring, unsuitable methods of fertiliser applications and poor drainage were the most common causes of retarded growth in young areas. Chronic defolia-

tion was another factor affecting development of trees in several areas visited, more particularly in young areas budded with clone PB 86. Gloeosporium leaf disease was usually the immediate cause of the defoliation but the incidence of infection was associated with poor vigour of the trees. There are clear indications that clone PB 86 is prone to attack by Gloeosporium but it is not clear whether it is actually more susceptible or whether the effect is more severe because of its relatively poor vigour. The evidence available suggests that other clones are equally susceptible but they resist the attack more effectively. It is generally recognised that clone PB 86 is one of the least vigorous of modern planting material and is usually recommended for large scale planting only on the better soil types.

In the course of visiting estates for advisory purposes it was observed that magnesium deficiency is widespread on young replanted areas and there is increasing use of magnesium lime and fertiliser mixtures containing magnesium. There was some evidence that potassium deficiency in mature rubber areas occurs more frequently than was previously supposed. A few small areas showing symptoms of iron deficiency were observed, but symptoms of deficiency of other minor nutrient elements, which can now be recognised, have not yet been observed in the field.

The Head of Division was called upon to visit several smallholdings in Kelantan to investigate the cause of backward growth of young replanted rubber growing in the heavy clay areas of the Kelantan Plain. An opportunity arose to make observations on methods of preparing land for replanting by the use of mechanised equipment. There were a few requests for visits to assess suitability of land for replanting and to advise on methods and treatment, also for assistance in planning the layout and suggesting treatments for replanting experiments.

G. Owen
Head of Soils Division

Botanical Division

Mr C. W. Brookson, Dr J. S. Lowe, Dr P. R. Wycherley, Mr T. V. Vaidyanathan and Mr V. K. Bhaskaran Nair were on duty throughout the year.

The Head of the Division Dr E. D. C. Baptist proceeded on long leave from 2 June until 15 December and Mr C. W. Brookson acted in his absence. Mr P. de Jonge was absent on sick leave in the Netherlands from 11 September until 22 October. On his return he was on light duty for one month.

The vacancy caused by the resignation of Mr H. M. Burkill in 1954 remained until 5 December 1955, when it was filled by the appointment of Mr J. M. Ross. Mr Ross took over all work concerning the development of material produced by the breeding programmes from Dr P. R. Wycherley. Dr Wycherley assumed responsibility for all work in connection with cover crops.

Mr Fong Fook Lam, Laboratory Assistant who had been in the employment of the Institute since 1937, resigned on 4 April at his own request in order to manage his own business. Mr Tan Lee Yeong, Laboratory Assistant resigned on 31 July to proceed to a course of further studies at his own expense in the United Kingdom. The vacancies thus caused were filled by the appointment of Mr Ting Keong and Mr Amal Kumar Dev on 1 September 1955. The latter resigned on 30 November to take up further employment before completing his probationary period. The vacancy thus occasioned had not been filled by the end of the year.

Mr Oh Eng Swee, Laboratory Assistant at the Botanical Division Laboratories at the R.R.I. Experiment Station, resigned on 30 November. He had been in the employment of the Institute since 1935. The vacancy occasioned by his resignation had not been filled by the end of the year.

Mr S. Anthonysamy, Laboratory Attendant, resigned on 31 October to take up an appointment as a junior Estate conductor. Mr P. C. Suppiah was engaged to fill the vacancy.

Research Officers made 78 advisory visits to Estates and 119 research visits. Junior Staff visited 132 Estates taking 547 days. In all 320 visits were made.

Graduate Officers made 376 visits to the R.R.I. Experiment Station, and Junior Staff twelve visits, a total of 388.

The following articles were prepared for the *Planters' Bulletin*, and published during the year:

Editorial—'More Rubber for Less Work'; 'R.R.I.M. 600 Series—Further Observations'; 'Further Legume Covers'; 'Poisoning Hevea with 2,4,5-T'; 'Planting Recommendations 1955—1956'; 'Yield Stimulation with 2,4,5-T'; Editorial— 'Fair Exchange'; Budgrafting Success'; 'Hanging Gardens'; Editorial— 'The True Pioneer'; 'Cover Seed Testing', in addition to a number of notes and communications from letters and the news columns.

Revision of the leaflet 'Suppliers of Clonal Seed' was made. A review on the 'Physiology of Latex' was prepared by J. S. Lowe. A paper on the 'Importation of New Strains of Hevea brasiliensis into Malaya' was submitted for publication by C. W. Brookson. Three papers by E. D. C. Baptist, E. D. C. Baptist and P. de Jonge and P. de Jonge respectively on the 'Stimulation of Yield in Hevea brasiliensis' were published as Communications 294 to 296 in the *Journal of the Rubber Research Institute of Malaya*.

Seven lectures were given to various organisations as follows:

'The Breeding and Selection of *Hevea brasiliensis*' by C. W. Brookson on 24 March to the Dindings District Planters Association;

'Yield Stimulation' by P. de Jonge on 21 April to the South Johore Branch of the Incorporated Society of Planters, 4 June to the Central Selangor Branch of the Incorporated Society of Planters and on 26 June to the Central Johore Branch of the Incorporated Society of Planters;

'Hevea Planting Material' by P. R. Wycherley on 27 January to the North Johore Branch of the Incorporated Society of Planters, 28 May to the Central Rural Branch of the Incorporated Society of Planters and on 5 November to the Central Selangor Branch of the Incorporated Society of Planters.

RESEARCH

BREEDING, SELECTION AND TESTING

Hand Pollinations

Conditions were favourable for this work during March and April, and a large amount of flowering occurred. Seven new families were obtained by crossing clones of the RRIM 600 Series with clones Tjir 1 and PB 86. A secondary object of the programme was to compare the value of the two latter clones as parents. Tjir 1 and PB 86 were crossed with clones RRIM 603 (PB 86 x Pil B84), 612 (AVROS 157 x PB 49) and 623 (Pil B84 x PB 49). The final results of the 1955 hand pollination programme are set out below.

1955 Hand Pollination Programme Results

Family	No. of pollinations	No. of points harvested	% success	No. of seeds planted	No. of seeds germinated	% of germination
Tjir 1 — RRIM 603	910	64	7.0	194	182	93.8
PB 86 — RRIM 603	1012	68	6.7	204	164	80.4
PB 86 — RRIM 605	1030	62	6.0	186	132	71.0
Tjir 1 — RRIM 612	919	77	8.4	231	163	70.6
PB 86 — RRIM 612	857	56	6.5	168	119	70.8
Tjir 1 — RRIM 623	225	24	10.7	72	51	70.8
PB 86 — RRIM 623	996	66	6.6	198	173	87.4
Total	5949	417	7.0	1253	984	78.5

The cross Tjir 1 x RRIM 623 showed above average compatibility, but the number of crosses was small compared to the six other families concerned. Between these six families there is probably no difference in compatibility.

Crosses Tjir 1 x RRIM 603, and PB 68 x RRIM 623 showed the highest germination, with 93.8% and 87.4% respectively. All the remaining families showed fair germination.

The programme was undertaken with a small number of expert pollinators, and it appears that manual skill plays a large part in the success of such a programme. Both the percentage success and the number of seed obtained were well over the average of results obtained since the Japanese Occupation.

Methods of Early Selection

Attempts to forecast the yield of untested clones were continued by counting latex vessels, and calculating sieve tube areas, and by preliminary testing, also in cooperation with the Soils Division by estimating petiolar rubber in various clones. Five hundred and forty bark samples from the 1952 hand pollinated seedlings were examined, and the sieve tube measurements were taken.

A preliminary test of clones RRIM 619 to 630 disclosed that RRIM 622 was superior on this criterion with a high degree of significance. Samples of leaves from the same large scale trial in hedge planting were also taken by the Soils Division in order to estimate the petiolar rubber, and to attempt to correlate the results thus obtained with the results of the preliminary test.

Seedling Families

Five hundred and eightynine stumps of seedlings obtained from the 1953 hand pollinations were planted in single tree plots in three replications by families at the R.R.I. Experiment Station, with a control of selfed seedlings of clone Tjir 1.

No collection was made from the area of 190 acres established on the R.R.I. Experiment Station under Colonial Development and Welfare Scheme D 1176 for the provision of high grade seed to smallholders. Seed in small quantities was again available.

Clones

Five hundred and eightynine new clones were made from the seedlings of the 1953 hand pollinations. These clones were budded in the field in six tree plots in a simple lattice design of two replications. Good success was obtained with the buddings. Clone RRIM 501 is used as the control.

In discard portions of this same area, two types of buddings of thirtysix clones were also made. Certain of the hand pollinated seedlings were allowed to branch, and clones were made from the stem (juvenile type) and branches (mature type) of the same seedling.

One hundred and twenty crown buddings of *Dothidella* resistant clone FX 1619, FX 25 and FX 3363 were made on three year old trees of clone RRIM 501 and

LCB 510 (PR 107). Three hundred and twelve branch buddings of the same three clones were made on four and a half year old trees of clone RRIM 501. It is hoped to initiate flowering by this means in 1956 in order that the resistance breeding programme can be commenced.

A small consignment of budwood of clones AVROS 1176, 1279 and 1301 was received from the Proefstation der AVROS. It has been reported that these clones display some degree of resistance to *Dothidella ulei*. They were budded in the nursery with a view to eventual multiplication, and steps were also taken to multiply the twentyfive clones received from America.

Export of eighteen of the *Dothidella* resistant clones took place early in the year. Export of the balance of eight clones was made to Research Institutes in Indonesia, Indochina and Ceylon at the end of the year.

Negotiations were opened by the Republic of Indonesia for a further exchange of eight clones with the United States Department of Agriculture, Plant Introduction Section. Provisional agreement was reached that the Institute should act as intermediary in the exchange, and employ the channels previously tried and found satisfactory. It is expected that these eight clones will be available in Malaya before the end of 1956.

The large scale trial of clone RRIM 600 to 618 at the R.R.I. Experiment Station was tapped on 1 October, clone RRIM 613 having reached the standard of twenty inches girth in 70% of the trees at the height of opening. Up to the end of the year clone RRIM 614 was the highest yielder, but little reliance can be placed on results obtained immediately after opening for tapping.

A very severe storm caused damage to certain small scale trials of the RRIM 600 series clones, notably RRIM 610 and 611 amongst others. The storm was so violent that the damage could not be attributed to normal windbreak. Records of the small scale trials of these clones are therefore now so unreliable that they will no longer be published.

Nine extremely vigorous clones have been observed in the clones from the 1947 and 1948 hand pollinated seedlings. Certain of these clones reached tappable size in three and a half years from budding. It has not proved practicable to tap the limited number of trees involved. It is proposed that they should be put into large scale trial as soon as possible.

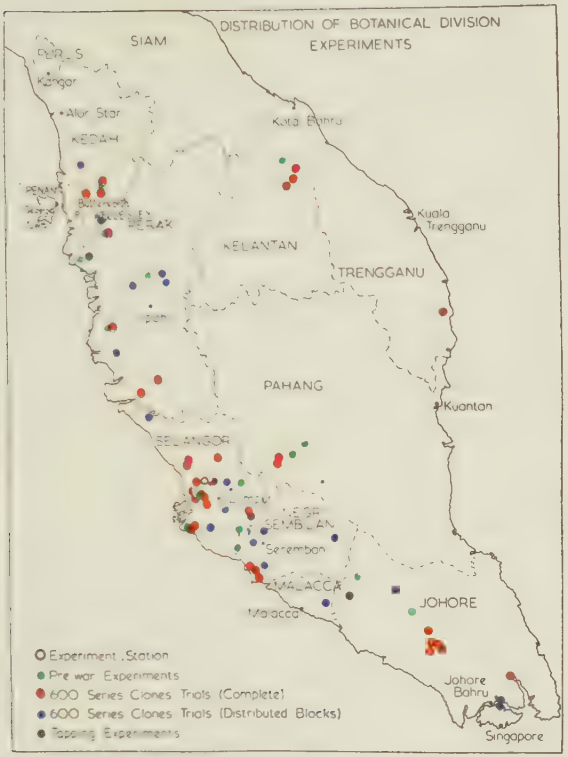
Tests by the Chemical Division continue on the latex and rubber of RRIM and foreign clones. Cooperation also continued in the study of variability of latex from Field 12 of the R.R.I. Experiment Station, by observation of leaf fall, seed fall and refoliation.

TRIALS OF SELECTED PLANTING MATERIAL ON ESTATES

Mature Trials

On coastal soils 12 trials on 4 estates totalling 465 acres remain in recording. They have all been visited by the officer-in-charge and field assistants during the year. On inland soils 14 trials on 11 estates totalling 581 acres remained in record-

ing at the end of the year. The recording of 5 trials on 3 estates (232 acres) was discontinued due to labour difficulties which resulted in irregular records of dubious value. With the exception of one trial in Kelantan, all were visited by a senior officer and/or field assistants.



Immature Trials on Estates

The 41 distributed blocks of 13 RRIM '600' series clones and RRIM 501, totalling 103 acres on 21 estates have remained under observation, all except 4 blocks on two estates were visited during the year by the officer in charge. The Senior Field Assistant has commenced measuring girths at 4 years from cutting back and making notes on the stand per acre, incidence of disease etc. This task was about half finished at the close of the year.

During the year a further 8 trials to compare from 6 to 13 clones in each were established. These were established on different estates and totalled 144 acres. Thus since the occupation 34 trials have been budded with new clones, mainly RRIM 600 to 630, on a total of 650 acres. Each of these trials, as distinct from the distributed blocks, is an entity sufficient to supply its own error. A quarter of these trials are on coastal soils.

As a result, with the exception of 4 clones, RRIM 600 — 630 are each represented at least 3 times on coastal soils and 4 times on inland soils. The 4 exceptions are clones which have proved somewhat disappointing since first selected, and in two cases are already covered by the distributed block experiment. The most promising clones have been allowed up to a total representation of 12 times. In some trials promising clones from other sources have been included.

Girths were measured in ten of the above trials. The officer in charge visited twenty already established trials and the sites for the trials set up during the year. Budding and supplying in the new trials was supervised by field assistants.

PROPAGATION & PLANTING TECHNIQUE

Planting Technique

No new experiments on this subject were set up during the year. The top budding experiment at the R.R.I. Experiment Station was examined with a view to final supply. The density of planting experiment was considered for thinning.

Tree Poisoning

A new tree poisoning experiment has been conducted during the year 1955 with the object of verifying findings made in preliminary experiments. The efficacy as a

tree killer of a 5% concentration of the normal butyl ester of 2,4,5-T in Diesel Oil was confirmed and it was found that the heavier grade cheap Fuel Oil was definitely not suitable as a carrier for this growth substance.

The poison was applied to a fifteen inch full circumference band from the ground upwards without any previous treatment of the trees. The yield of the trees increased to a high level for a period of one month and then dropped gradually to zero.

When tapping of the poisoned trees was done in an upward direction, the tapping cut thus moving away from the poisoned strip, increased yields at a high level were obtained for a period exceeding ten weeks. Tapping was done on a half circumference cut at alternate daily intervals. Nearly all trees were killed within 6 months, only a few exceptionally vigorous trees surviving for a longer period. The roots however, were only slowly affected, and it is not yet possible to determine the time required to kill all roots. A few living roots have been found on trees carefully poisoned eighteen months ago of which the stems were completely disintegrated. A 2½% concentration of 2,4,5-T in Diesel Oil was nearly as effective as the 5% concentration in killing trees and stimulating the yield.

TAPPING

Conventional Tapping

Yield recording continued during the year in 13 tapping experiments, 7 on the R.R.I. Experiment Station, 5 on estates and one on a smallholding of the Smallholders' Advisory Service. Two more tapping experiments have been designed for layout on cooperating estates. Nine out of the total number of 13 tapping experiments in progress concentrate on full circumference tapping systems.

Generally a retarding effect on growth has been established in all experiments (six in total) in which full spiral tapping was done from the time the stand reached tappable size. On older material no clear cut retarding effect on growth has yet been found. A comparison made between S/1.d/4.100%, S/1.d/3.9m/12.100%, S/1.d/2.2m/4.100% and S/2.d/2.100% systems showed that there is not much to choose between the first two which both yielded more than the S/1.d/2.2m/4.100% system during five years of tapping. During the first three years of tapping the yield of the control (S/2.d/2.100%) was similar to that of the trees tapped with a full spiral system, but when new cuts had to be opened on the control trees in bark of second renewal, the yield dropped sharply, resulting in an apparent advantage for the full spiral systems. No increased brown bast incidence due to full spiral tapping was found but the girth increments were slightly depressed by the full circumference systems.

To overcome the disadvantages of full circumference fourth daily tapping, introduction of resting periods resulting in full spiral tapping systems of 67% and 75% relative intensity was investigated. Very marked clonal differences in response to S/1.d/4.100% tapping were established. Clones Tjir 16 and Ct 88 reacted unfavourably with a progressive drop in yield, and clones AVROS 71, BD 10, AVROS 256 and AVROS 50 showed a gradually increasing yield on full spiral fourth daily tapping. The introduction of resting periods had a positive effect only on clones Tjir 16 and Ct 88, the yield level of the periodically tapped trees slowly increasing to that of the trees tapped on S/1.d/4.100% system. None of the clones which could stand S/1.d/4.100% tapping showed much response to the introduction of resting periods.

An apparent improvement for all periodic systems occurred when the tapping cuts of the trees tapped on S/1.d/4.100% system were changed over into bark of second renewal resulting in a steep drop in yield. If the periodic systems have had a beneficial effect on bark renewal this should show up in coming years when the periodic systems will also be in bark of second renewal. The overall yield of the periodic system to date after seven years experimental tapping still shows a clear loss of 17% relative to the S/1.d/4.100% system.

In a small scale experiment carried out on trees of the same clones as in the preceeding experiment a slow but steady increase from year to year relative to S/1.d/4.100% tapping was obtained by S/1.d/5.80% and S/1.d/6.67% intensity tapping systems. A very marked drop in yield was experienced when the tapping cuts of the 100% system were changed over into bark of second renewal in the sixth year of tapping and a similar effect occurred when the cuts of the S/1.d/5.80% system were opened in bark of second renewal in the seventh year of tapping.

Coming years will show if the renewed bark of trees tapped on the lower intensity systems will yield better than those of the S/1.d/4.100% tapped trees. To date there is a loss of 10% for the S/1.d/5.80% system and of 20% for the S/1.d/6.67% relative to the S/1.d/4.100% system after seven years continuous tapping.

Two experiments are in progress, and one has been designed, in which tapping systems for use on high yielding planting material susceptible to brown bast are being studied. The results available covering a period of two years are as yet too few to allow definite conclusions but the indications are that the so called 'change-over' systems such as S/2.d/2.2x12m/24 are less effective in combating brown bast than simple third daily tapping of a half circumference cut. One tapping cum manuring experiment has been designed for layout on a cooperating estate.

High or 'Ladder' Tapping

An experiment is in progress on a 1927 trial of budded trees of nine clones which have given disappointing yields on bark of second renewal. Three tapping treatments are compared namely high tapping on virgin bark (V/2.d/2.100%), low tapping on bark of second renewal (S/2.d/2.100%), and 2C/2.d/2.100%, a high V-cut in virgin bark and a low S/2. cut in renewed bark, both cuts tapped on the same day at alternate daily intervals.

All clones showed a higher yield on high tapping, but marked clonal differences were found with clones PB 186, Pil A44 and Pil B84 showing outstanding yield increases. The overall yield increase due to high tapping was 63% in the first year of tapping and 150% for the 2C/2.d/2.200% system. It appears that there is little effect if any on the yield of the low cuts from the high cut at the opposit side of the trees, provided there is a distance of 50 — 60 inches between the two cuts. Similar results have been obtained from an experiment done on old unselected seedling trees. The experiments continue.

The Chemical Division has made investigations into the properties of latex and rubber from high and low cuts.

One tapping experiment carried out on Tjir 1 buddings, on a smallholding of the Smallholders' Advisory Service, has shown a consistently slightly higher yield for the smallholders tapping system in which daily tapping is done for 24 days out of 30 on a third spiral cut, when compared with S/2.d/2.100% tapping. No differences have been found with regard to dry rubber content, brown bast incidence, percentage of lower grades and girthing.

PHYSIOLOGY AND MORPHOLOGY

Biosynthesis of Rubber

Illegitimate seedlings were germinated in washed sand and transferred to culture solutions. These seedlings were then subjected to a variety of treatments. Growth and rubber synthesis was arrested by excising the endosperm food reserve and placing the seedlings in the dark; slow growth and a slight increase in rubber formed were observed if the seedlings were allowed to retain their food reserve. One per cent sucrose in the culture solution could replace the excised food reserves over the five week term of the experiment.

In the dark, acetone at M/500 added twice weekly gave significant increases in the rubber content of seedlings. In the light M/800 acetate also gave increased rubber content. These experiments, however, are not exacting enough, and it is considered that it will be extremely difficult to influence significantly the proportion of rubber formation to growth. However in view of the claims made, these experiments were continued. An attempt was made to repeat the work of H.J. Teas (Puerto Rico) who claimed 50% increase in rubber in island bark as a result of acetate treatment.

Trees due to be thinned out in a clone trial were taken and three of each of clones RRIM 614 and 613 had their bark cut into two 4-foot high islands. One island on each tree was treated daily with 200 ml of M/500 acetate spray. The experiment was continued for 6 weeks. The Wiley mill caused some of the rubber to form small pellets when the dried bark was being powdered and it has been necessary to do rubber estimations of the entire islands of bark and not of selected samples. The complete results are not yet available.

There is some evidence from the literature that Indoleacetic acid controls the direction of acetate metabolism and favours the lipoid and sterol synthesis. Since rubber is allied to the sterols attempts have been made by using acetate together with indole-acetic acid and an S-H linkage activator, cysteine to influence the metabolism of bark islands and seedlings towards increased rubber synthesis. No results are as yet available.

An experiment was started to see how long 5% 2,4,5-T in diesoline remains toxic to hevea when added to soil and to dead root material. Attempts were made to get the transmission of 5% 2,4,5-T from treated seedlings to untreated seedlings either by root contact, diffusion through the soil solution or root grafts. The report of the results obtained awaits confirmation from the work of other Divisions.

Work on the culture of hevea callus tissue continue to prove unsuccessful. An *Avena* coleoptile extensive assay was tested for use in estimating the auxin content of hevea bark.

Yield Stimulation

A full account of the work on yield stimulation up to 1955 has been given in Communications 294-296 of the *Journal of the R.R.I.Malaya* 'Stimulation of Yield in Hevea brasiliensis'. The 1% acid equivalent concentration of the normal butyl ester of 2,4,5-T in a mixture of palm oil and petrolatum has appeared the cheapest and most satisfactory yield stimulant if applied to a 3 inch strip of scraped bark below the tapping cut.

Long term experiments on seedlings and budded trees continued. Eight successive half-yearly applications of stimulants have been given in one experiment and the

downward trend in response which was observed during the first two years appears to have come to a halt. Nearly similar increases have been recorded after the fifth, sixth and seventh application. The yield level has never dropped below that of untreated control trees. A check was made on the properties of latex and rubber after the eighth application of treatments and no abnormalities were found. Damage to tapping panels and stems of trees injected with copper sulphate became worse after each successive injection, but the effect on the yield was still highly satisfactory.

Half yearly application of a stimulant on buddings of nine clones tapped on bark of second renewal has also given satisfactory results and after five successive applications no signs of unfavourable response have yet been observed. In an experiment carried out on buddings of clone AVROS 50, budded in 1930 high increases in yield (plus 60%) were obtained during eighteen months of monthly treatment above the tapping cut with a stimulant. During the following eighteen months the yield decreased gradually to a more or less constant level of 25% above that of the non-treated trees.

The thickness of treated strips of renewed bark was greatly increased during the first year after treatment by excessive formation of phelloderm and phellem tissue. However, the renewal during the third year after commencement of the experiment was better on the non-treated trees. It is thought that the excessive stone cell development in the bark of the treated trees interferes with the normal dilation of bark tissue. It has been proved beyond doubt that the activity of the tree cambium is not increased by the use of yield stimulants.

Eleven other so-called 'stimulators of bark renewal' have been tried out in this experiment and all of them induced a thicker periderm layer during the first year, but the renewal of untreated trees was more vigorous than that of trees treated with any of the mixtures included in this experiment during the third experimental year. No increase in brown bast incidence has been noted in any of these long term experiments.

Six new yield stimulating experiments have been set up during the year 1955 at the R.R.I. Experiment Station, but as only two months results were available at the end of the year it would serve no purpose to discuss at this stage the merits of the various systems and mixtures employed.

The first experiment was on clonal seedlings tapped on bark of second renewal, and a comparison is being made between several yield stimulating mixtures applied at different intervals either below or above the tapping cut. The second, third, fourth and fifth experiments are on unselected seedlings tapped on thin bark of second renewal. In the second experiment high tapping of a V/2 cut in the virgin bark was compared with low tapping of an S/2 cut in the renewed bark and with the 2C/2.d/2.200% system which proved so promising on buddings of nine clones as discussed under 'Tapping.' Several systems of yield stimulant applications are confounded with these tapping treatments and the method of recording allows the study of the mutual influence between high and low cuts. Alternate daily upward and downward tapping of a half circumference cut in the virgin bark are compared in the third experiment, confounded with or without yield stimulant application. The latex and rubber of these treatments were studied by our Chemical Division.

A further effort to determine the optimum concentration of 2,4,5-T in the standard carrier of palm oil and petroleum is being made in experiment four.

In experiments five and six, efforts were made to find a carrier for 2,4,5-T which would penetrate through non-scraped bark layers. In an experiment done on a co-operating estate the effect of a yield stimulant on the growth of young Tjir 1 buddings was studied. No significant effect on growth had been established during the six months after the first application of the stimulant.

In an aerial spraying experiment in which our Pathological Division defoliated trees with various concentrations of 2,4,5-T in Diesolene an increase in yield of sprayed trees was established.

Anatomy

Investigations into the anatomical composition of seedlings grown under controlled deficient conditions revealed two outstanding abnormalities. First, absence of calcium oxalate crystals in plants grown without calcium and secondly a high calcium oxalate crystal concentration in the boron-deficient plants. No clear cut abnormalities were found for other deficiencies except that the poorly grown plants deficient in phosphate, nitrogen and iron had a high starch content in both wood and bark.

ECOLOGY

Cover Crops

Identification of cover crop species has continued.

Certain aspects of the method used for testing seed of legumes have been investigated. It was concluded that the greatest chance of error occurs in the selection of the sample for testing from the bulk lot by the supplier. The methods used by this Division give reliable estimates of the various fractions — good, bad and foreign seed, dirt and chaff. The germination tests employed here use larger samples than appears to be common practice elsewhere. The tests employed give a good estimate of total viability and fraction of hard seed. The values for the former compare well with those obtained by other methods, the latter is neglected in other techniques.

It is suggested that the lower results obtained by this Division compared with those obtained in seed producing countries prior to shipment of the seed may in fact reveal a real deterioration in seed quality during transit. A standard form for recording the results for internal use and notification of the supplier has been introduced.

In view of the poor quality of imported seed, investigations have been continued or initiated along the following lines: firstly the distribution to estates of nucleus quantities of *Flemingia congesta* seed. Further good reports on this cover were received. The Experiment Station is able to supply a small surplus over its own requirements. Estates must however be further stimulated to produce their own seed. Secondly the promotion of seed production of leguminous cover crops is being investigated.

The search for new cover plants has included the propagation of a new legume received from Chamek Estate. It appears to be a species of *Clitoria*, new to Malaya and shows promise under certain conditions. Three leguminous species have been received in an exchange with the Grassland Research Station, Department of Agriculture, Kitale, Kenya. These are *Desmodium unicatum*, *Lotononis bainesii* and *Teramnus repens*

Ecological Studies

Studies of the flora of the R.R.I. Experiment Station have continued.

ADVISORY

Tours and visits—Seventyeight purely advisory visits by Research Officers were made to Estates on request. On the other 119 visits made, advisory requests were also met in addition to the experimental object of the visit.

Correspondence

A further significant increase in the amount of correspondence received and despatched during the year must be noticed. Measured against previous years the trend is as follows:

	1952	*1953*	*1954*	*1955*
Letters received	1484	1502	2363	2825
Visitors to the Division	89	75	114	132
Visits to Estates	49	122	129	197
Samples received for examination or identification	76	93	89	88

The number of letters despatched in reply to enquiries was 2685, an increase of 20% over the 1954 total of 2230. The number of letters despatched on purely advisory subjects was 1679, an increase of 45% over the 1954 total of 1116. The increase in correspondence was thus due solely to the extra number of advisory letters called for over the previous years total, an indication of the increasing recognition of the practical value of the Division's work.

In the following paragraphs the advisory correspondence is analysed under the major sections of the research programme, and commented upon.

Breeding & Selection

Fifteen enquiries were received concerning the establishment of seed gardens and the selection of seed producing areas. In connection with similar enquiries under another heading, identification of clones on estates, on which point 246 letters were received, some special notes are required and are shown in the next paragraph.

The volume of work under this heading during the year has been considerably increased by reason of two tasks undertaken for the Department of Agriculture. These were firstly the inspection of all Government budwood nurseries supplying smallholders and secondly the rogueing of clonal seed collection areas which supply material for the Smallholders' Replanting Scheme. The latter is the larger task and has only been begun.

The results so far have indicated that some nurseries and seed collection areas are in excellent condition, but there are exceptions. These latter constitute such a real risk in areas where planting material derived from them is used, that the objects of the replanting scheme may be defeated, or at least individual smallholders exposed to serious losses. Therefore, although the programme of work which has been undertaken will heavily strain the resources of the Division, it is incumbent on the Institute to provide such services as far as possible, to prevent worse eventualities from being realised.

A further identification mandor was trained during the year to meet the increased work involved in this major task, and the organisation of tours for three identification experts, and the necessary individual expert comments on each report by them, involved considerable work on the part of the Research Officers concerned.

Rubber seed samples were received from thirtytwo estates for identification, which was not possible in the case of four seedling samples.

The largest number of queries under this section were those concerned with the choice of planting material for use in new plantings and replantings.

Propagation and Planting Technique

Fiftyfour queries were received under this heading, dealing with planting distances and the desirability of employing hedge planting. .Thirtyfive letters were received on the subject of tree poisoning.

Tapping

Enquiries on this subject numbered 121, a decrease over the previous year. The principles of ladder tapping now appear to be better understood, and not so much advice is being sought on this subject.

Fiftysix letters were received on the subject of the yield in commercial tapping of buddings and clonal seedlings.

Physiology

With the publication of articles in the *Planters' Bulletin* correspondence on the subject of yield stimulation decreased, and only 101 letters were received.

Ecology

Routine advisory work under this section consisted of the identification of plants received from Estates. One hundred and fifty letters were received and 145 despatched in connection with these and other identifications.

A small amount of seed of *Flemingia congesta* was again distributed to Estates in nucleus amounts.

Germination tests were laid out on samples of leguminous cover crop seeds.

General Planting Enquiries

Seventythree enquiries of a general nature were received.

Visitors

One hundred and thirtytwo visitors were received in the Division, and twentyseven visitors were taken round the R.R.I. Experiment Station by Officers of the Division during the year. This latter figure includes only visitors specifically for the Division.

Budwood

Budwood of RRIM clones sold to Estates for multiplication and use in new plantings and replantings amounted to 2887 yards for the RRIM 500 Series clones and 8308 yards for the RRIM 600 Series clones. Three hundred and seventyseven yards of budwood of other clones was also sold, making a total of 11,572 yards.

C. W. Brookson
Acting Head of Botanical Division

Pathological Division

The Field Research Officer (Mr F. W. Hutchison) acted as Head of Division in the absence of Dr A. Newsam on home leave, from 14 March to 16 December. The Pathologist (Mr R. N. Hilton), Assistant Pathologist (Mr K. P. John) and Microbiologist (Mr R. A. Fox) were on duty throughout the year. The Assistant Entomologist (Mr B. S. Rao) left Kuala Lumpur on 27 August to attend a one-year course in Plant Protection at Long Ashton Research Station, University of Bristol.

On his return to the United Kingdom Dr Newsam visited America, to meet officers of the United States Department of Agriculture and the Foreign Operations Administration (now the International Cooperation Administration) concerned with rubber research in the New World. In the course of his tour he visited the U.S.D.A. Plant Introduction Garden at Miami, Florida, and the Cooperative Research Station in Guatemala, Costa Rica, Brazil and Peru. The tour was most kindly arranged by Dr Loren G. Polhamus, Head of the Rubber Crop Section of the Field Crops Research Branch, U.S.D.A., now retired.

Mr F. W. Hutchison lectured on root disease to three planting associations — in North Johore on 24 February, South Johore on 13 August, and West Pahang on 3 September.

A review of South American leaf blight by Mr R. N. Hilton was published as Communication 293 in the *Journal* of the R.R.I. of Malaya. Advisory articles contributed to *Planters' Bulletin* comprised the following subjects: replanting a bad root disease area; pink disease; bird's eye spot; termites; dieback; slugs and snails.

RESEARCH

DISEASES OF THE ROOT SYSTEM

Field experiments—The fourth and fifth rounds of inspection and treatment have been carried out in experiment G-50, which is a comparison of stump poisoning treatments. The incidence of root disease in the young stand, now 5 years old, is falling to a low level; the final result of the experiment, therefore, will not be much different from the present position which is that stump poisoning generally has reduced the incidence of disease by about 60% over the first five years, during which time routine control has been carried out.

The third and fourth rounds of inspection and treatment have been carried out in experiment CI-51 on coastal alluvial soil, where stump poisoning is being compared with poisoning the standing trees. The beneficial effect of poisoning stumps as compared with leaving them untreated is here not so marked, the reduction in incidence on the young trees over four years being only about 30%. A possible explanation of the smaller effect of stump poisoning in this experiment is that much surface timber was left in the area and it may have had the effect of spreading root disease, which was mostly *Fomes lignosus*. Tree poisoning gave most satisfactory results, reducing the incidence of infection of the young stand by about 80%. Experiment CI-51 was also designed to test the effect of preplanting disease eradication. Trees in the old stand known to be infected were winched over but left on the ground. This has not proved

a successful method of dealing with them, for the amount of disease in the young stand has in some blocks been higher than in those where no eradication was attempted. Savings on subsequent root disease control have been small compared with the cost of the preplanting measures. The experiment also includes three methods of dealing with disease in the young planting: collar inspection followed by eradication; foliage inspection followed by eradication, and no treatment. Because the first two procedures lead to the early recognition of disease on the trees and their removal where they are considered to be beyond saving, losses in the young stand are initially higher. This does not indicate that control measures are unnecessary, for it must be expected that losses will continue indefinitely in the absence of treatment, whereas in the treated areas there are now few new cases of attack. It is too early to draw conclusions about the relative advantages of collar inspection and of detecting disease by the appearance of foliage. The indications so far are that foliage inspection is satisfactory; indeed, where collar inspections have been carried out the total incidence of disease has been greater. If this is due purely to earlier recognition it will in time be offset by a rise in incidence on the trees where the foliage only is inspected; but there may be other factors operating.

Of the experiment put down in 1954 (WC-54) there is nothing to record except that the method of marking the positions of diseased trees in the old stand has not proved satisfactory.

Rate of loss of infectivity of diseased root fragments—This experiment has come to an end with the almost complete disintegration of the surviving roots after 44 months burial. Of the three diseases, *Ganoderma pseudoferreum* persisted rather longer than *Fomes noxius* and *Fomes lignosus*, between which there is little difference.

Effect of fumigants on Fomes lignosus—Preliminary tests with two proprietary soil fumigants have shown them to be highly poisonous to rubber trees as well as to the root parasites. The more toxic of the two has been applied experimentally to seven trees six years old, the trees having previously been artificially infected with *Fomes lignosus*. The trees and the fungus were killed by the treatment. The fumigant would be of practical value in replanting if it were found to destroy the parasite in the roots of a large tree or stump.

Susceptibility of jungle trees to the root diseases of rubber—All the root diseases of rubber are presumed to have spread originally from infected indigenous trees. The susceptibility of jungle trees is therefore of interest in relation to new plantings. To get more information about this some 40 species in the jungle at Sungei Buloh have been inoculated with the three common rubber root parasites, using pieces of naturally infected rubber root.

Spore infection tests with Fomes lignosus—Stump infections which had apparently started from spores of *Fomes lignosus* have been seen in the field, but have not been brought about experimentally on a convincing scale. In new inoculation tests made on the stumps of thinned out trees the spore suspension was sprayed on to the cut surfaces immediately after felling, treated stumps being then covered with paper, mulch, or soil, or combinations of these. Six out of fourteen stumps that were covered with soil (with or without paper or mulch first) developed infections attributable to the inoculum. There were also cases of natural infection of the experimental stumps, with *Fomes noxius, Poria hypobrunnea, Ustulina zonata* and *Sphaerostilbe repens*.

Fundamental Studies of Fomes lignosus

Field observations—Little mycelium has been found in the soil where experiment CI-51 is located. This is in marked contrast to the position a year ago. The factors that control activity of the fungus are yet undetermined. Detailed notes on developing

fructifications are being compiled as a step towards resolving the problem of the proper name of the fungus. The extent to which an infected tree should be treated has been examined. The usual advice is to strip off superficial fungal growth, excise all penetrated tissue, and treat the roots with a 2% solution of copper sulphate. It seems, however, that isolated fragments of rhizomorph and mycelium are harmless and will die away. In some circumstances the fungus will even die out from lengths of penetrated roots that are left on the tree, instead of being fully excised. Advice on the treatment of attacked trees may therefore need to be revised, when the factors involved are more fully understood.

Laboratory investigations—In a like manner the use of copper sulphate must be called in question since it had been found that the strains of the fungus *in vitro* can become adapted to tolerate copper sulphate in solution at a concentration of 1%.

For the identification of the fungus in culture, a deep tube technique using modified Jensen's medium had been found most satisfactory. Of more than forty species examined only one had a growth pattern at all resembling that of *Fomes lignosus* and it could be easily distinguished. In petri dish culture there are considerable variations between different strains of *Fomes lignosus*.

The effect of hydrogen ion concentration on the rate and form growth *in vitro*, in particular rhizomorph initiation, has been studied in detail. Most rapid growth occurs at a little below neutrality, but there are other, smaller, optima at lower hydrogen ion concentrations. Rhizomorph formation is initiated in acid conditions — at neutrality the fungus produces a diffuse mycelial growth. Detailed observations on the effect of temperature await the installation of new equipment. The fungus is susceptible to desiccation but is relatively tolerant of high temperatures when the humidity is high also. Growth is not much inhibited by light.

Most emphasis in these fundamental studies of *Fomes lignosus* has been given to investigating antagonism in the broad sense. One possible aspect of biological control has been investigated by studying common fungi that destroy wood and might therefore compete with *Fomes lignosus*. Another approach has been to study certain streptomycetes that parasitise the root parasites. Some produce inhibitory substances in culture, as do cultures of other soil and wood rotting organisms including *Fomes lignosus* itself, which may thereby be assisted in colonising dead wood, as it has been found to do.

DISEASES OF THE TAPPING PANEL

Testing a new mouldy rot fungicide—Laboratory and field tests have been carried out with a proprietary tar acid fungicide submitted for official approval as a mouldy rot fungicide. It has been found harmless to newly tapped bark at a concentration of 20%, but the concentration at which it gives a satisfactory control of the disease in the field has yet to be determined.

SECONDARY LEAF FALL

Thirtyseven reports of secondary leaf fall were received during March, April and May in response to the annually distributed circular. Their distribution is shown in the Table. Examination of 116 specimens sent in gave the results shown in the second Table, in which the mean intensity of attack, calculated as in 1953, is also shown. *Oidium* attacks were lighter than usual, and the severity of secondary leaf fall correspondingly was less. In two outbreaks reported in the second half of the year *Oidium* was the dominant parasite.

Distribution of Reports of Secondary Leaf Fall

Territory	March	April	May	Total
Kedah	6	—	—	6
Perak	2	3	1	6
Selangor	6	3	—	9
Negri Sembilan	2	6	1	9
Johore	5	—	1	6
Pahang	—	1	—	1
Totals	21	13	3	37

Incidence of the Parasites Associated with Cases of Secondary Leaf Fall

Parasite	Percentage of cases in which present		no other parasite present	Mean intensity of attack
	March	April/May		
Oidium	56	44	5	2.1
Gloeosporium	39	61	2	2.4
Mites	40	60	2	1.8
Thrips	50	50	0	1.5

Dusting clone BD 5 with Vitospor ZX—Twentyfive-year-old trees of BD 5 in the Experiment Station were dusted with Vitospor ZX once a week for a year. The rate of application was heavy, eight pounds being applied to 170 trees. Despite this, and the effectiveness of the fungicide against *Gloeosporium* in vitro, no improvement in the canopy was seen.

OTHER LEAF DISEASES

Bird's eye spot.—In collaboration with the Soils Division an experiment has been started to see whether nutrition has an effect on susceptibility to attack by *Helminthosporium heveae*. The plants are growing in sand culture in pots in the open. Spores of the fungus have been introduced to provide an initial inoculum.

DEFENCE AGAINST SOUTH AMERICAN LEAF BLIGHT

Aerial spraying trials—Experimental aerial applications of normal butyl 2,4,5-T made during 1955 have completed the preparatory work in connection with the eradicant campaign proposed in the event of *Dothidella ulei* being introduced into Malaya. Preparations for the final airborne trials were made last year, in continuation of the

experiments carried out in 1953. The objects were to decide on a concentration and rate of application, to discover how often the treatment needed to be repeated, and to observe the long term effects on the trees. The results are not yet fully analysed. The detailed plan for an eradicant campaign that has been published* is complete except for recommendations as to dosage and frequency of application.

STEM AND BRANCH DISEASES

Pink disease—A close study of the disease is being made with the chief intention of discovering how it spreads. The pink crust (which is the most conspicuous form that the fungus takes), the cobweb stage that precedes it, and the pustular form that is a variant of it, are all sterile. Two spore forms are known. One, called the Necator stage, is commonly found on the upper surface of a branch killed by the disease. The other sporulating form, which appears briefly on the pink crust, has rarely been encountered in these investigations.

The course of infection has been followed by making artificial inoculations on brown wood with pieces of infected bark or with pure cultures of the fungus. Spore inoculations have not been successful; moreover, the fungus does not appear to liberate spores freely in the air. Other possible methods of dissemination are therefore being investigated. In addition, the distribution of pink disease outbreaks throughout Malaya is being plotted, using RRIM 501 as indicator clone because of its marked susceptibility to the disease.

INJURIES OF NON-PARASITIC ORIGIN

Treatment of fire damage—The present advice for treating burnt trees is to scrape away any damaged tissue immediately after the fire, and to apply a wound treatment. It has now been found that the full extent of the damage may not be seen until many days later. Invasion by boring beetles being the main hazard to be guarded against, a protective dressing should immediately be applied and followed later by treating the wounds when their full extent can be seen. Experimental application of limewash and other materials alone or combined with it have not given protection against borers. There is a need for further experiments on these lines, which can be put down only when an accidental fire lays open a sufficiently large area to borer attack.

TERMITES

Control measures—Applications of aldrin, dieldrin and chlordane in emulsified form have given lasting protection to trees attacked by termites on the Experiment Station. In Field 55, where these materials have been in use since June 1954, a few trees have been reattacked in parts of the field where there is a peat soil. In Fields 18, 51 and 52 there has been a spectacular decline in the incidence of termite attack since the changeover from 1% mercuric chloride, previously the standard treatment. In twelve months only one case of reattack of a treated tree has been recorded in these three fields, despite the fact that some disturbance of the treated soil has resulted from root disease inspections.

The persistence of aldrin, dieldrin and chlordane in soil has been investigated by taking samples from around treated trees for observations on residual toxicity. After more than two years the treated soils have been found to retain their toxicity. The effect of soil type has been investigated by treating samples of six different soils with the same three insecticides and with endrin, afterwards storing them in pots buried in the ground in the open. Monthly tests of their toxicity to termites has shown that

* *J. Rubb. Res. Inst. Malaya* Communication 293 section IX.

peat rapidly destroys or inactivates all four insecticides, this observation explaining the partial failure of termite treatments in peat areas on the Experiment Station. The toxicity of chlordane was falling off in all the soils after four months, and of endrin in clay after 7 months. The other soil/insecticide combinations have so far remained toxic for 10 months.

OTHER INSECT PESTS

Mites—Karathane W. D., a fungicide reported to be effective against mites, was tested for the control of *Hemitarsonemus latus* and Tetranychids. At a concentration of 0.1% it killed nymphs and adults but was not ovicidal. It caused slight scorching of young flushes.

NEMATODES

Cover plants attacked by eelworms—To get some idea of the distribution of eelworms in the field a survey has been made of the covers in the immature areas on the Experiment Station. The three common legume creeping covers — *Centrosema pubescens, Pueraria phaseoloides and Calopogonium mucunoides*, were all infested, as were *Flemingia congesta, Desmodium ovalifolium* and *D.polycarpum*. In addition eelworm galls were seen on nine non-leguminous cover plants. Susceptibility tests have been carried out in pots in the air-conditioned glasshouse with eight legume covers. Those that became infested by eelworms derived from galls on *Calopogonium mucunoides* were (in addition to *Calopogonium*) *Desmodium ovalifolium Mimosa invisa*, and *Indigofera endecaphylla*. *Centrosema pubescens, Pueraria phaseoloides, Stylosanthes gracilis* and *S.sundaica* were not attacked.

ROOT NODULE BACTERIA

Preparation of a Rhizobium compost—An increasing demand for *Rhizobium* cultures for inoculating cover crop seed has made it desirable to develop a bacterial compost as a more suitable medium for distribution. The method has been found satisfactory, the inoculum being fully effective and its activity well maintained in storage. The basic materials for the composts used in these tests have been peat and coir dust, the latter being preferred. Various additions are being tried to see whether multiplication of the bacteria or nodulation of inoculated covers can be further improved.

MISCELLANEOUS INVESTIGATIONS

Pollination of hevea—Further observations have been made on the insect visitors to hevea flowers. Thrips were seen most frequently and at all times of day. Midges were more numerous in the evening. As further evidence against wind pollination of hevea (if further evidence be needed) no pollen grains were found in a spore trap that was operated continuously during the flowering season.

ADVISORY

Root Diseases

Being the major pathological factor in rubber cultivation, the control of root diseases is the largest single subject dealt with in our advisory work. No novel developments have arisen in this connection during the year. In general the enquiries reveal that

too much importance is attached to applying a fungicide in treating root disease in young rubber. By far the most important operations in control work are cutting off the diseased parts of the root system and eradicating or isolating sources of infection. Removing old stumps because they have bracket fructifications on them is not advised, partly because many fungi produce somewhat similar fruit bodies, partly because even a diseased stump may rot away without infecting any young trees. The cut surfaces of pruned roots should be treated with a wound dressing and, until further evidence shows it to be unnecessary, superficial growth of the fungus is best removed or poisoned.

A tree infected with white root disease may be rapidly killed by the fungus destroying the bark round the collar, where covers are allowed to grow closely round the tree, creating the necessary damp conditions. This situation was referred to on page 100 of *Planters' Bulletin 15* as indicating that the infection started at the collar from contact with diseased *Pueraria* roots. The same effect can arise if the tree has become infected in the much more usual way of a lateral root making contact with infected timber in soil. Once the fungus reaches the collar it rapidly spreads over, penetrates and kills the bark if the collar is shaded by vegetation.

Diseases of the Tapping Panel

No case of black stripe was brought to our notice during the year, and enquiries about the treatment of mouldy rot have fallen away almost to nothing. It would seem that panel diseases are generally well under control.

Leaf Diseases

There have been few enquiries on bird's eye spot, though it is still a very common nursery disease. An article in *Planters' Bulletin 18* advocates manuring affected plants rather than applying fungicides, which have little effect. *Gloeosporium* leaf disease has again been found more troublesome on PB 86 than on young buddings of other clones. Reports of secondary leaf fall have been discussed under 'Investigations'.

Stem and Branch Diseases

Advisory correspondence about pink disease — by far the most serious branch infection — has fallen to a third of that in 1954. This is perhaps the result of an article about it being published in *Planters' Bulletin 18*. Bordeaux mixture, recommended for areas not in tapping, has proved most efficacious. There have been several reports of drought-induced dieback of clones Gl 1 and RRIM 512. A general article on dieback has been published in *Planters' Bulletin 20*.

Injuries of Non-Parasitic Origin

Some observations on the treatment of fire damage have been made under 'Investigations'. With lightning damage and accidental poisoning with sodium arsenite the question is usually one of recognition; the symptoms of both have now been described in the article in *Planters' Bulletin 17* on wounds and their treatment. Sunscorch of the leaves of basket seedlings is encountered where they have been planted in the open without previously hardening them off in the nursery by progressively removing the shade. The leaves have a bleached appearance, in patches or over the whole lamina. An example of local burning through drops of water acting as lenses was the subject of a letter in *Planters' Bulletin 20*. In light coloured soils seedlings may also be scorched near the base of the stem by reflected heat. Mulching helps to avoid the latter trouble. The first leaves put out by replanted stumps too are liable to wilting or scorching, there being no root system to replace water lost by transpiration. Bark bursts, with latex bleeding and burr formation, continue to attract attention because

of their pathological appearance although they are purely physiological in origin. Clones PB 86 and PB 5/37 are conspicuously liable to bleed, but this is not harmful.

Insects Pests

The problem of controlling termites attacking rubber may be regarded as solved, now that there are available chlorinated hydrocarbon insecticides which remain effective over long periods at low concentrations in the soil. An article on the subject appeared in *Planters' Bulletin 19*. Cockchafer outbreaks have occurred in several places but on a small scale. The species most concerned was *Holotrichia bidentata*, to a less extent *Leucopholis rorida*. Cases of attack by the common scale insects and mealy bugs have been recorded but showed no original features. The leaf deformation caused by *Planococcus citri* has again been seen, and heavy outbreaks of *Lepidosaphes cocculi* on young PB 86 trees. An attack of *Scirtothrips dorsalis* of exceptional severity caused defoliation in a young replanting. Caterpillars of three species of moth have been found eating renewed bark, but such attacks are not of any consequence. Lepidoptera are more troublesome as pests of cover plants. To control them and other leaf eating insects 0.5% lead arsenate can be used on *Centrosema*, but on *Pueraria* and *Calopogonium*, which are liable to be scorched by lead arsenate, an emulsion of dieldrin has been recommended and has given good results.

Nematodes

An eelworm infestation of *Desmodium* has been found on an estate — the first report of its kind for many years. It was not established to what extent the nematodes accounted for the partial failure of the cover, which was also attacked by leaf eating insects.

Other Animal Pests

The type of injury that has been attributed to woodpeckers (*Planters' Bulletin 3*, page 61) has been observed in North Borneo, but proof of the identity of the pest responsible for cutting these bands in the bark of young trees is still lacking. A letter about bats chewing the leaves of clone Gl 1, without touching other clones, appeared in *Planters' Bulletin 18*. As a result our attention was drawn to an account of exactly the same occurrence in Ceylon (*Quart. Circ. Ceylon Rubb. Res. Sch.* 22(1945)39). Among the larger animals that damage rubber plantations bordering the jungle, deer give the most trouble. Damage from slugs and snails can be locally severe. An article on these pests has been published in *Planters' Bulletin 21*. It has been reported that tree banding is a useful measure of control that can be applied in addition to baiting with Meta.

Root Nodule Bacteria

Four thousand six hundred and fourteen tubes of *Rhizobium* culture were sent on request for inoculating cover crop seed. Monthly checks on the continued effectiveness of the strain distributed have been maintained using *Centrosema pubescens* as the test plant.

Summary of Advisory Work and Correspondence

Letters despatched	1201
Specimens examined	313
Visits to estates and smallholdings	155
Interviews	79

Arthur Newsam
Head of Pathological Division

Chemical Division

The graduate staff of the Division at the commencement of 1955, comprised Mr W. G. Wren (Head of Division), Mr G. W. Drake, Dr W. A. Southorn, Mr L. L. Best, Mr H. M. Edmondson, Mr R. S. Gale, Mr J. E. Morris, Mr D. J. Graham, Mr P. F. Maher, Mr D. H. Taysum, Mr K. C. Sekar, Mr R. C. H. Hsia, Mr B. C. Sekhar and Mr S. J. Tata.

Dr R. Freeman, seconded from the British Rubber Producers' Research Association (B.R.P.R.A.), continued working in the laboratories until April.

Mr D. J. Graham continued to divide his duties between Experiment Station Staff and Chemical Division Staff.

Mr Best proceeded on leave in March, and resigned later in the year. Mr Gale proceeded on leave in January and returned for duties in October. Mr G. W. Drake returned from leave in April. Mr B. C. Sekhar proceeded on leave in September. Mr. P. F. Maher resigned part way through his tour in October.

New staff comprise Mr G. F. J. Moir, who took up his duties as Biochemist in February and Mr ST. Sethu, Assistant Chemical Engineer, who joined the staff in September.

The posts of Analyst and Chemical Engineer for development work remained vacant throughout the year, despite constant efforts to recruit new staff. Attempts to recruit new staff for work on the technical classification of rubber, replacing Messrs Best and Maher have been unsuccessful to date.

Liaison has been maintained between the Committee of Malayan Latex Technologists and the British Standards Institution Sub-Committee RUC/10/7. which deals with methods of latex testing. Contact has also been maintained with Committee D-11, Sub-Committee XII of the American Society for Testing Materials, which deals with raw rubber, and with the International Standards Organisation. Constant exchange of views has been maintained with sister Research Institutes, with the International Rubber Research Board (I.R.R.B) and with the International Rubber Development Committee (I.R.D.C.), the Head of the Division having attended the Inter-staff Symposium and the Directors' Meetings, arranged in Paris by these organisations during June.

The Head of Division, together with a member of the staff, attended the International Rubber Quality and Packing Conference held in New York in May, representing the RRIM, and the IRRB, as well as assisting the Malayan Delegation as technical advisers. Whilst in the U.S.A. contact was made with the research and technical staffs of the larger rubber manufacturers, embracing valuable discussions as well as visits to laboratories and factories.

During May and June the Head of Division attended meetings of the London Advisory Committee, the L.A C. Technical Sub-Committee, and the B.R.D.B. Road Surfacing Committee in London, as well as holding a number of informal discussions with the staffs of the B.R.P.R.A., the L.A.C., the Biochemical Department of Birmingham University, and representatives of the rubber trade and rubber manufacturers, etc. During Mr Wren's absence from Malaya, Mr Drake acted as Head of Division.

Contributions to recognised journals were published as follows:

'Volatile Acids and the Quality of Concentrated Natural Latex,' by A. S. Cook & K. C. Sekar in the *Journal of the Rubber Research Institute of Malaya;*

'Effect of Sulphuric Acid Coagulation on Properties of Natural Rubber,' by L. L. Best & S. H. Morrell in *Transactions of the Institution of the Rubber Industry;*

'The Proteins of *Hevea brasiliensis* Latex,' by B. L. Archer & B. C. Sekhar in The *Biochemical Journal.*

Articles published in the *Planters' Bulletin* comprised: 'Life in Latex', 'Superior Processing Crepe' and 'Smoke-houses'.

The following Chemical Memoranda and Chemical Division Reports for limited circulation were issued:

C/M. 15 — Manufacture of Cyclised Rubber Masterbatch in Malaya

C/M. 18 — Memorandum on Patents

The following publication concerning technical classification was published under the aegis of the I.R.R.B.:

Technical Bulletin No. 34 — World Output of T.C.R. in 1954

The following notes for local circulation were issued in connection with technical classification:

TC Note 11/54 — Annual Report on Progress in the Technical Classification of Malayan Rubber 1954

TC Note 1/55 — Technical Co-ordination of T.C.R. Production

TC Note 2/55 — Report on Progress in the Technical Classification of Malayan Rubber in 1955

TC Note 3/55 — Comparison of Strain and Rate of Cure Testing Methods for the Large Scale Testing of Rubber Samples.

An account of the work carried out by the Division is presented below in two main sections, 'Research Investigations' and 'Advisory & Development.'

RESEARCH INVESTIGATIONS

Research investigations have been directed towards three main objectives:

1 To prepare rubber more cheaply, and to improve quality, uniformity, presentation, etc.

2 To improve the control of latex concentrate production, with a view to producing latex of higher quality and uniformity, particular attention being given to retaining the foam rubber market for natural as opposed to synthetic latices.

3 To produce special and modified rubbers with a view to competing with synthetic rubber and plastics as special purpose materials.

The account of research investigations which follows is given under five major sections, as follows:

Non-Rubber Constituents

Latex, Chemistry and Technology

Dry Rubber, Chemistry and Technology

Special and Modified Rubbers

Preparation and Presentation.

A small number of *ad hoc* investigations, mostly arising from advisory enquiries, are also reported.

NON-RUBBER CONSTITUENTS

Microbiological Survey of Malayan Latex

The importance of bacteria in hevea latex preservation has been apparent for many years, but very little information was available when systematic investigations were started at the R.R.I. two or three years ago. The first stage of the investigations, which has now been completed, comprised a survey of the bacterial population of hevea latex as normally harvested, of field latex preserved with 0.3% ammonia and of ammoniated latex concentrate (0.7% on the latex). A total of 800 strains of bacteria have been isolated and studied from latices prepared under the usual conditions of commercial production. Although several yeasts and fungi have been isolated from hevea latex, there is no evidence of either proliferating in ammoniated latex systems.

The next stage of the investigation has now been commenced and consists in an attempt to attribute to the more important strains the chief metabolic roles played in a latex environment. The Table on page 48 gives a summary of the most important families of bacteria found in latex, together with their occurrence in the three types of latex studied, and their likely behaviour in latex.

It will be seen from the tabulation that bacterial survival ammoniated latices is considerable and very disperse. In ammoniated field latex the most dangerous survivors appear to be acid forming Lactobacteriaceae, particularly Streptococci and Propionibacteria; the Coliforms also survive in large numbers. There exist also, small numbers of Bacillaceae, which have a destabilising effect upon latex if permitted to proliferate. At the higher levels of ammonia which obtain in latex concentrate, the Bacillaceae appear to be the most dangerous survivors. They occur in most of the concentrates examined so far and can breed under factory conditions to be fully resistant to this level of ammonia, the growth rate well exceeding the death rate. The Lactobacteriaceae which survive higher concentrations of ammonia are also potential trouble-makers. It is not difficult to obtain bactericides which will satisfactorily combat these infections, but other requirements, such as compatibility with latex, non-interference with processes in which the latex is subsequently used, and low cost, make the task a somewhat complicated one. A number of new preservative systems have been examined for bactericidal and bacteriostatic effects as described later in this report.

Growth Rates of Bacteria in Latex

The growth rates of the mixed bacterial population of latex have been determined with considerable accuracy.

When latex is collected in cups under normal 'dirty' conditions the first or lag phase, during which the rate of growth is relatively slow, lasts for 2½ to 3 hours; with sensibly sterile cups, the duration is from 4 to 4½ hours. The mean generation time, assuming the population to be homogeneous, is just under 1 hour. Duration of the second or log phase, in which rate of proliferation is rapid and follows

FAMILIES OF BACTERIA FOUND IN MALAYAN LATICES

Family	Number of species observed	Occurrence in fresh latex, ammoniated (0.3%) field latex & ammoniated (0.7%) concentrate	Known dominant behaviour, not yet established in latex, unless stated
Nitrobacteriaceae	2	Rare, environment not suitable	Derived from soil and water, these organisms oxidise ammonia to nitrite
Pseudomonodaceae	10	Fairly widespread in fresh latex, but not in large numbers. Do not thrive in ammoniated latex	Derived largely from water; metabolic processes include oxidation of alcohols, reduction of sulphate to sulphide, proteolysis, acid production from carbohydrates. Long chain hydrocarbons and polysaccharides may also be attacked
Azotobacteriaceae	1	Fairly common in fresh and ammoniated field latex. Survival in concentrate is doubtful	Fixation of atmospheric nitrogen
Micrococeaceae	12	Family occurs widely in fresh latex. Some species are widespread in ammoniated latex and in concentrate	Acid production from carbohydrates (but no evidence that quebrachitol is decomposed), and proteolysis. Some strains produce exotoxins. Probably responsible for most of the colours displayed by poorly preserved latex
Lactobacteriaceae	20	Species occur in all types of latex. The great majority of bacteria in ammoniated field latex belong to this family. Survival in concentrate is common under present conditions	A large variety of carbohydrates are converted to low molecular weight carboxylic acids. Probably responsible for natural coagulation of hevea latex. Proteolysis is weak. Amino acids assimilated. Some strains produce toxins

Corynebacteriaceae	2	Rather rare	Slow proteolysis and acid production, usually weak. Hydrogen sulphide can be evolved. Produce some colouration
Achromobacteriaceae	3	Species occur in all types of latex	Some species produce strong colour changes. Acid production from carbohydrates is possible, but probably not important in latex. Amino acids can be utilised
Enterobacteriaceae	16	Widespread occurrence in field latex. Permanent survival in concentrate is rare	Produce acid and gas from a wide range of carbohydrates. Three species produce acid from quebrachitol. Proteolysis is usually weak; amino acid metabolism is widespread. Probably the first species to proliferate after tapping
Bacteriaceae	5	Species occur in all types of latex, some rare, some very common	Probably of little importance in latex, but can produce pigments in sheet and crepe rubber
Bacillaceae	20	Species occur in all types of latex, some rare, some very common	Actively proteolytic and produce exotoxins
Actinomycetaceae	5	Not observed in fresh latex. Some species are common in ammoniated latices	May affect viscosity, due to production of continuous networks. Slow attack of rubber hydrocarbon. Responsible for surface discolouration of poorly preserved latex
Streptomycetaceae	6	Species occur in all types of latex, but most commonly in concentrate	Viscosity changes. Slow attack of rubber hydrocarbon
Mycobacteriaceae	1	Observed in fresh but not in ammoniated latex	Viscosity changes. Slow attack of rubber hydrocarbon

an exponential law, is 7 to 10 hours. The population at the time of collecting field latex averages 8 x 10^6 bacteria per millilitre. This can rise to 4 x 10^9 before natural coagulation occurs.

In the case of field latex ammoniated to 0.3%, the average generation time is much greater, averaging 18 hours. The population depends upon the degree of infection at the time of ammoniating but ranges from 1 x 10^5 to 1 x 10^7 bacteria per millilitre. Ammoniated latex concentrate (0.7%) shows a population ranging from zero to 1 x 10^5 bacteria per millilitre, depending upon the degree to which resistance to higher levels of ammonia has been allowed to develop. The average generation time is very high, being about 6 days.

Bacterial Deproteinisation of Latex Skim

The possibility of deproteinising skim latex by bacterial digestion has been studied and removal of 50% of the nitrogen achieved. The process at present does not compare favourably with trypsin digestion, which gives 80% removal of nitrogen. On the other hand bacterial digestion may prove to be somewhat less expensive and it is hoped to make further trials with a view to obtaining more complete removal of the protein. Up to the present all species used belong to the genus Bacillus (Cohn), strains of *Bacillus cereus* and *Bacillus cereus* var, *mycoides* having been found amongst the most effective; these strains can readily be isolated from ammoniated latex concentrate.

Latex Serum as Bacteriologic Medium

Incidental to the main lines of investigation, the possibility of developing bacteriologic media from waste serum has been briefly examined. Serum from acid coagulation for sheet preparation after neutralising by the addition of sodium hydroxide, was found to provide a bacterial growth medium of the highest order. Over 200 strains of bacteria from a variety of genera have been succesfully cultured on the medium. The possibility of using such media commercially in the local production of compounds derivable from the metabolism of micro-organisms should obviously not be ignored.

Estimation of Bacteria in Mixed Culture

In the course of the investigation, it became apparent that a method for estimating the number of individual strains in a mixed bacterial culture is essential if accurate and reliable counts are required. Existing methods were either unsuitable or insufficiently accurate. A method has been developed based on light scattering at particular frequencies using ultra violet and near infrared spectrophotometry.

The scattering of radiation at the latex particle serum interface has also been analysed and estimates of the mean diameter of latex particles determined. Interpretation of the data is complicated and the method appears rather more suited to studies involving comparisons between latices rather than absolute measurements.

Enzyme Activity in Latex

The study of enzymes occurring in different latex fractions has been continued in the laboratories. One of the most interesting aspects of this work is the picture which is being built up of the bottom fraction obtained on high speed centrifuging of fresh latex. Although only tentative conclusions can be drawn at present, there is much evidence to suggest that the bottom fraction possesses a particulate structure

and a useful working hypothesis is to postulate cell-like bodies, which contain serum of a different composition to that of the bulk latex. Thus after washing bottom fraction and centrifuging off all free aqueous material, a further supply of 'serum' may be obtained by freezing, thawing and recentrifuging, suggesting that by freezing the walls of the cell-like bodies can be broken and their contents released. To distinguish between the two 'sera', the designations serum C for bulk, and serum BF for bottom fraction are employed. It has also been observed that bottom fraction undergoes volume changes when immersed in solutions of different tonicity, which again suggests bodies surrounded by a semi-permeable membrane.

Working with these fractions the following observations have been made:

Catalase—Catalase activity is shown by whole latex, but is much more marked in serum C and serum BF. In gereral, the catalase activity of latex is less than that found in most plant tissues. Thus at 30°C one gram of serum C solids was found capable of decomposing 1.5×10^{-3} milli-moles of hydrogen peroxide per minute.

The enzymve remains active after dialysis, and shows maximum activity in a buffer solution at pH 6 to 7.

DOPA and polyphenol oxidases—DOPA oxidase has not been found in serum C but is present in serum BF; treatment with 30% acetone gives a precipitate which contains the bulk of the DOPA oxidase. Polyphenol oxidase is found both in serum C and serum BF. Attempts to separate the enzyme have so far been unsuccessful as the reagents used have been found to cause deactivation.

Both enzymes attain maximum activity between pH 6 and 6.5, and become inactive under strongly alkaline conditions.

Dialysed fresh latex which by itself cannot be clotted by the usual acid coagulants, was found to be coagulated in the presence of DOPA, pyrocatechol and pyrogallol, suggesting that DOPA oxidase and polyphenol oxidase play a part in latex coagulation. This activity recalls the early observations of DE VRIES (*Arch. Rubbercult* 8 (1924) 226, 264) to explain which he postulated an enzyme 'coalase'; without this enzyme it was not possible to obtain a coherent coagulum from fresh latex.

DOPA and polyphenol oxidase activities in latex have also been shown to correlate with discolouration in air-dried sheet prepared with it. Observations suggest that latex discolouration occurs when more substrate and fewer inhibitors are present; so far it has not been possible to demonstrate discolouration as characteristic of a given clone. Reducing agents such as cyanide, metabisulphite, hyposulphate, hydrosulphite are effective in preventing the darkening; they also inhibit the oxygen absorption associated with activity of the enzymes.

Oxygen absorption of latex—Oxygen absorption by fresh latex fractions appears to be due mainly to DOPA oxidase and polyphenol oxidase, other enzymes such as peroxidase and ascorbic acid oxidase, playing a minor part. Since the oxidases are strongly inhibited in whole latex, the latter shows little or no oxygen absorption immediately after tapping and collection. Bacterial oxidation normally commences some three to four hours after tapping and collection, but then proceeds at a fairly high rate. Ammoniation appears to accelerate non-enzymic, non-bacterial absorption of oxygen by latex but not enzymic absorption. The implication of these observations is that the oxygen absorption of ammoniated latex is largely non-enzymic, but may be both chemical and bacterial.

Decarboxylating activity—Both pyruvate and α-ketoglutorate carboxylases have been found present in serum C. Only slight DOPA decarboxylating activity was observed, but there is indirect evidence that the bulk of the enzyme is contained in the cell like bodies of the bottom fraction.

Separation of decarboxylating enzymes has proved difficult, owing to denaturation of the enzymes by the reagents employed.

Urease—No urease activity has been demonstrated in serum C or in serum BF.

Freeze-dried Latex Fractions

The biochemical work of the Division has as its main objective, the provision of information on certain non-rubber substances which influence the properties of latex and dry rubber. The main advance in this work during the past few years has been the development of a means for preparing latex fractions using high speed centrifuging and freeze drying. This permits the handling and storage of latex fractions in a relatively unchanged condition, so that investigation of particular non-rubber substances can be carried out as required.

Supply of material to the U.K.—Investigations on latex fractions as obtained at present have been continued both in Malaya and in the U.K., where the B.R.P.R.A. and Professor Stacey's laboratory at Birmingham University have been supplied with freeze-dried materials prepared in Malaya.

Work at B.R.P.R.A. on freeze-dried serum solids has developed a means of separating and identifying latex proteins using paper electrophoresis. Similar apparatus has now been set up in the R.R.I. laboratories and a programme of work commenced, which will survey the proteins occurring in latex from different clones and at different seasons. Proteins are known to be important in controlling the colloidal properties of latex and the present study should throw some light on problems connected with latex coagulation, drying of rubber and the mechanical stability of latex concentrates.

The work at Birmingham University has demonstrated the presence in latex of an enzyme, aldolase, which might be concerned with the biosynthesis of rubber. As relatively small concentrations have been found, large quantities of freeze-dried materials are needed to continue the investigation. Work has therefore been undertaken at the R.R.I. in an attempt to provide a latex fraction rich in this particular enzyme and so reduce the work involved in preparing adequate supplies of freeze-dried material.

Carbohydrates in latex—Observations on sera obtained by acid coagulation of latex collected at weekly intervals, showed no noteworthy variation throughout the year in the carbohydrates present. The presence of l-inositol, myo-inositol, quebrachitol and reducing sugars was confirmed. Methods for more reliable quantitative estimation of carbohydrates are now being studied.

LATEX CHEMISTRY AND TECHNOLOGY

Seasonal Changes in Latex

Although considerable information is available concerning seasonal changes in the technical properties of latex concentrate and smoked sheet, very little is known about changes in other properties, such as mineral content of fresh latex, enzyme activity and so on. A large scale experiment was therefore planned to cover at least two wintering periods, and put into operation in January, 1955.

Latex is being collected at regular intervals from a group of mixed seedling trees at the Experiment Station, and concentrate prepared under strictly standard conditions, using a laboratory centrifuge. Sheet and whole latex rubber are also being prepared from the bulk latex collection. Observations include the following: condition of trees, weather, bacterial content of latex and concentrate, enzyme activity of fresh latex fractions, chemical analysis of latex and latex concentrate dried films, technical properties of latex concentrate, molecular characteristics of the dry rubber, vulcanising behaviour of sheet and whole latex rubber and so on. In all about one hundred observations are made on each collection of latex. The analysis of the data is somewhat lengthy, but simplified methods have been worked out and the observations are already yielding some interesting data. The most surprising feature to date is the lack of variation in many of the properties examined, with the implication that variability in commercial supplies may originate in lack of uniformity in field and factory procedures rather than in the trees themselves. Not all properties remain constant however; thus enzyme activity, phosphorus content of fresh latex and vulcanising characteristics of sheet and whole latex rubber showed significant variations during the year.

Recently the experiment has been extended to include latex collection from two clonal areas, Tjir 1 and RRIM 501.

Concentrate Prepared with RRIM 600 Series Clones

The properties of concentrates prepared with latex from the RRIM 600 series clones were examined in connection with the trials discussed below in the section dealing with dry rubber.

From the point of view of mechanical stability the latices appeared to be satisfactory for concentrate preparation, with the exception of RRIM 600, 608, 616, 626, 627, 628 and 630. Certain clones showed a very high mechanical stability, which usually developed soon after preparation; these were RRIM 603, 604, 606, 609 and 623. Concentrates prepared from RRIM 601, 604, 610 and 613 were pale yellow in colour, the rest having the normal white appearance.

It should be emphasised that these results were obtained on latex from only six single trees of each clone and thus take no account of many factors which influence latex properties. Trials with blocks of trees grown in different localities are essential before any conclusions can be drawn regarding likely behaviour of the different clones.

Preservation of Latex

Four new systems for preserving latex have been investigated during the year. In the first case, attempts were made to produce a neutral latex concentrate. It was found that by the addition of formaldehyde to latex concentrate immediately after centrifuging, the remaining 0.15 to 0.2% ammonia could be converted to hexamethylene tetramine, lowering the pH to the region 6.8 to 7.2, and producing a concentrate of low mechanical stability. By the addition of suitable surface active materials, a neutral concentrate was obtained having a mechanical stability in the normal range and showing good behaviour on coagulation. The latex which contained no free ammonia remained in a satisfactory condition for two to three months, after which time thickening set in. More work requires to be done before a satisfactory product can be obtained.

On discussing the merits of a neutral latex concentrate with consumers, however, it became apparent that in most instances, latex having a low ammonia content would be preferred. Thus in the production of foam rubber by the silicofluoride

gelling process, about 0.2% of ammonia is essential. Work on neutral concentrates has therefore been suspended until definite applications for such latices are known.

The second system investigated employs boric acid with ammonia in low concentrations. This system has been found reasonably successful as an anti-coagulant for field latex, as a short term preservative for factory use and as a long term preservative for concentrate. It has also been employed successfully in conjunction with a sequestering agent for concentrate preservation. Small trial shipments to the United Kingdom are being made for evaluation by B.R.P.R.A.

In the third instance, experiments have been carried out with anti-biotics as bactericides. Trials with a number of materials resulted in a combination which was very effective in killing the bacteria normally present in hevea latex. Further work has shown that effective long term preservation of latex concentrate can be obtained with a combination of four antibiotics and low ammonia content. The system appears to be less effective for short term preservation. It is hoped to make trial shipments to the U.K. in the near future. Further work with other antibiotic materials is envisaged.

The other system investigated comprised the use of sulpha-derivatives together with low concentrations of ammonia. Trials with these materials are continuing.

Application for patent protection has been made in the last three cases, viz. boric acid, antibiotics and sulpha drugs. Further work requires to be carried out on each of the systems before any can be established as satisfactory.

Effect of Temperature on Latex Concentrate

It has long been known that freshly prepared latex concentrate continues to increase in mechanical stability for a number of months after preparation. This renders assessment of concentrate quality before shipment a difficult task, particularly as on receipt by the consumer the properties are usually required to be within certain limits.

Recent experiments have shown that the rate at which the change in properties occurs is temperature dependant. Thus at normal storage temperatures, say 30°C, the peak mechanical stability may not be reached for six months. At 40°C, however, it is reached in under 30 days, and at 50°C in a matter of some five days. It should be recorded, however, that the maximum stability developed is also temperature dependant and within the limits examined the higher the temperature of storage the lower the mechanical stability attained.

There appears to be a reasonably good agreement between the stability reached after three months' storage at room temperature and that attained after five days at 50°C. This fact has been made the basis of an accelerated storage test for latex concentrates and forms a valuable guide for assessing the behaviour of a given concentrate at a later date.

The accelerated change in properties at higher temperatures has also been employed to produce a latex concentrate with much more constant properties. After heating at 80°C for a few hours, latex concentrates show a low mechanical stability, of the order of 100 seconds. This remains unchanged after storage for some months. By the addition of suitable stabilising agents, a concentrate showing the required mechanical stability and good behaviour on coagulation can be produced, the properties of which remain reasonably constant over long periods. This work is not being followed up at present, owing to the problem of heating large bulks of concentrate at 80°C, which is a costly process.

Changes in Ammoniated Concentrate on Storage

One of the gravest defects of natural latex concentrates is the change in properties which proceed after concentration and continue for an indefinite period. The reactions involved are very complex and it is apparent that complete understanding of the changes involved will not be attained for a number of years.

Recent work has confirmed earlier findings that availability of oxygen is a very important factor in controlling the rate at which increase in mechanical stability occurs. The presence of gaseous oxygen, peroxides or other oxidising agents markedly increases the rate, whereas lack of gaseous oxygen and the presence of reducing agents both have a definite retarding influence. It has been demonstrated that although in any one latex concentrate the amount of free higher fatty acid increases on storage apparently in correlation with the increase in mechanical stability, no correlation can be established between the amount of higher fatty acids present and the mechanical stability of a series of latices. In fact, by modifying the availability of oxygen, the mechanical stability developed by a given concentrate can be changed at will, but the amount of higher fatty acid liberated does not appear to be influenced. Two latices from the same parent bulk can thus develop widely different mechanical stabilities, and yet have the same amount of higher fatty acid present.

Experiments have shown, however, that the surface activity of higher fatty acids extracted from different latices can be significantly different, and it remains to be demonstrated, whether the type of fatty acid produced is a controlling factor for mechanical stability.

Work is in hand which attempts to correlate oxygen absorption with the development of mechanical stability and the surface activity of fatty acids liberated on storage. The role of proteins in conferring mechanical stability is also being studied in conjunction with this work.

Mechanism of Latex Coagulation

Torsiometer experiments—The study of latex coagulation has been continued during the year, using the torsiometers which had already been constructed for this purpose. It was found necessary to add a preservative to the latex used for these experiments, as fresh field latex putrefied too quickly to permit satisfactory observations. In the first series of experiments 0.2% ammonia was used.

Coagulation of lightly ammoniated field latex was found to be markedly dependent on temperature; within the range 14°C to 65°C, the higher the temperature the more rapid the coagulation and the tougher the coagulum formed. Storage of the latex for a few hours at a given temperature before coagulating, enhanced the effects observed. At temperatures above 70°C or so, the rate of coagulation appeared to be reduced and even fell to zero. Under these conditions the rubber globules appear to flocculate, and do not form a coherent coagulum. Exposure for even a few seconds to a temperature of 90°C — 100°C destroys the power to form a coherent coagulum, as first recorded by de Vries (*loc. cit.*).

The effect of formaldehyde as a preservative instead of ammonia, was then studied. Earlier work had shown that the addition of 0.1% of formaldehyde to field latex accelerates coagulation. If the latex is stored for some hours in the presence of formaldehyde however, the effect is no longer observed and coagulation may even be retarded. Further work has now indicated that the system is a complex one and the reactions proceeding are by no means completely understood. The addition of

formaldehyde brings about a series of changes in the latex. In the early stages this appears to promote coagulation, but in the later stages a flocculant precipitate may be formed instead of the usual coherent hydrogel. The time taken to pass through the different stages depends upon a number of factors, including temperature and the concentration of formaldehyde. At room temperatures (say 28—30°), the initial stage takes some hours to complete; at temperatures above 45°C the initial stage is completed so swiftly that it often escapes detection. At concentrations for formaldehyde lower than 0.1%, the results become somewhat anomalous probably due to bacterial proliferation.

Adhesion experiments—Earlier experiments made with the torsiometer showed that after three or four days the strength of latex coagulum markedly increased. On the basis of these observations it was thought that in the initial stages of coagulum formation, cohesion between particles was not necessarily due to rubber contacts, but that these developed much later. In order to investigate this question further, one of the torsiometers was modified to measure the cohesion between two fresh rubber surfaces after pressing together under a small standard load for a given time. The surfaces were kept below the surface of an aqueous medium, which permitted control of pH, surface activity, etc.

It was found that adhesion was strong and rapid between rubber surfaces under those conditions which would promote coagulation of latex. Thus lowering of the pH and absence of surface active constituents were conducive to rapid adhesion. All the evidence supported the view that coagulation of latex involved immediate rubber to rubber contacts, which was contrary to earlier views. Some of the earlier work was therefore repeated and the observations checked. Evidence has now been found which suggests that the marked increase in structural strength of coagulum which occurs after three days may be due to bacteria. Our observations now indicate that rubber to rubber linkages are important right from the first onset of coagulation and it is thought that the controlling factors are those which determine the rate of formation of rubber contacts between particles.

Construction of a prototype torsiometer—The usefulness of the torsiometer as a research instrument had been confirmed and further tests gave indications of its usefulness as a control instrument for latex foam production; a few enquiries from other Research Institutes also showed interest in acquiring the apparatus. The question of obtaining further instruments had thus to be considered and it was decided to build a new model which could serve as a prototype on which to base commercial production of further machines. The prototype machine has now been constructed and has proved satisfactory in trials both for latex coagulation studies and in foam rubber production. It is hoped that commercial production of further machines will be possible during 1956.

Estimation of Rubber Content

An attempt was made to develop a rapid method for determining the dry rubber content of latex, using the spectrophotometer to measure the light scattered at the rubber water interface as indicating the concentration of particles present. The method gave a rapid estimation of dry rubber content, but results did not agree very closely with the values given by the B.S.I. method. In general, closer agreement was found with the rubber hydrocarbon content of the dried film determined by the chromic acid oxidation method. Factors interfering with the spectrophotometric

measurements appeared to be variation in particle size from latex to latex and in the non-rubber constituents of the serum. The method at present is regarded as unsuitable for the estimation of d.r.c. as normally understood.

DRY RUBBER—CHEMISTRY AND TECHNOLOGY

Molecular Characteristics

Investigations to study the molecular character of the rubber hydrocarbon have now been brought to a conclusion, although routine testing to observe seasonal and clonal differences in the hydrocarbon are being continued.

During the past few years it has been established that two hydrocarbon components occur in hevea rubber, a soluble portion having an average molecular weight of one million, and an insoluble or gel portion, which occurs in latex and freshly prepared rubber as discrete particles, referred to as microgel. The microgel fraction can be precipitated from solutions of rubber by high speed centrifuging and by the addition of certain dry powders.

Examination of rubbers from a number of clones has now shown differences in the molecular weight of the soluble portion and differences in the proportion of microgel present; seasonal differences also occur. As far as can be judged at present, the variations in these characteristics are too small to be of importance to the rubber technologist. It is considered possible, however, that they may be of significance in other connections, such, for example, as the preparation of modified rubbers and rubber graft polymers. For this reason further data are being collected on a routine basis.

Test Procedures

Contact has been maintained with different Committees of the British Standards Institution and the American Society for Testing Materials in connection with the development of specifications for materials and test procedures, including both dry rubber and latex.

A simple test based upon specific gravity has been worked out to permit easy distinction between skim rubbers and normal R.M.A. types. Trials with a number of skim rubbers showed the test to be satisfactory. It was also shown that chemical analysis such as the determination of nitrogen content, ash, acetone extract, etc., provides an accurate method of distinguishing skim from other types.

Details of a specification for superior processing crepe have been worked out, including a simple extrusion test, to permit ready quality control of factory production.

RRIM Clones, 600 Series

An examination has been made of latex and dry rubber harvested from trees comprising the RRIM 600 series at the Experiment Station. The trees have been in tapping between six and nine years, using the half-spiral alternate daily system.

Examination of the latex total solids showed that the non-rubber content was greater than that of the control trees employed, Pil B84 and Tjir 1, the nitrogen, magnesium and ash contents being consistently high. The alcohol extract was found to differ from one tree to another, ranging in one experiment from 4% for RRIM 605 to over 7.5% for RRIM 612, 614, and 624; the control trees Pil B84

and Tjir 1 showed values of about 6.5%. The relative proportions of magnesium to phosphorus varied considerably, magnesium being in excess for clones RRIM 601, 608, 616, 622, 628, and 630, whereas phosphorus was in excess for clones RRIM 609, 612, 619, 623, 624, 625 and 627.

Smoked sheet prepared with the latices showed the usual range of colour; the hardness also covered the usual range for smoked sheets, high Mooney values being shown for RRIM 608, 615, 616, 622 and 629, and low values for 603, 605, 606, 617 and 620.

Vulcanising behaviour showed the rubbers to be a little more scorchy than the average run of sheets, the vulcanisates in most cases showing good tension strength and a high modulus. Of the 29 rubbers examined by the T.C.R. test method, 23 gave 'blue' rubber, five 'yellow' and one 'red.' Ageing characteristics appeared to be normal.

Crepes prepared with the latices show a wide range in colour from good white comparable with BD 5, for RRIM 600, 609, 612, 615, 616, 628 to deep yellow for RRIM 601, 604, 605, 607, 629. The hardness also covered a fairly wide range being as hard or harder than Tjir 1 for RRIM 608, 623, 624 and 629; the softest clones were RRIM 603, 604, 605, 617 and 619. Most of the rubbers showed good resistance to sunlight ageing, the best being RRIM 617, 621 and 624. Resistance to oven ageing showed a rather wide range of behaviour, the most resistant being RRIM 607, 611, 616 and 624, the least resistant being 613, 628 and 629.

It must again be emphasised that the above data on the 600 series clones was obtained on latices harvested from six single trees grown at the Sungei Buloh Experiment Station, and are recorded only as preliminary observations. The behaviour of these clones under other conditions may be very different and the results of larger trials in a number of localities must be awaited before conclusions can be drawn regarding the characteristics of rubber from these clones.

Yield Stimulation

Further observations have confirmed earlier findings that the technological properties of rubber from trees treated with yield stimulant 2,4,5-T, are normal, and in no way inferior to rubber from untreated trees.

SPECIAL AND MODIFIED RUBBERS

Cyclised Rubber

Experimental work on cyclised rubber has been confined to trials with an alternative stabiliser, which was found to be suitable for purposes of preparation. The properties of the product obtained were not satisfactory however, and the stabiliser cannot be recommended for use.

Samples of cyclised rubber from three manufacturers have been tested with a view to maintaining quality control of the production; the samples examined represented some 80 tons of commercially produced cyclised rubber masterbatch.

Superior Processing Rubber

Considerable demand for trial quantities of superior processing rubber have been received; so far all reports have shown that technical behaviour is very satisfactory. In all, 23 tons were produced at the Experiment Station factory, most of the material being sent to the U.K. with a little to the U.S.A. Commercial production under licence from the Board has now been undertaken by one company.

Production, so far has been in the form of crepe, as sheet has been found to be less satisfactory. In view of the considerable interest shown by consumers in the material it is hoped shortly to carry out further investigations with a view to producing satisfactory superior processing sheet, thus enabling consumers to obtain a superior processing rubber at lower cost.

Partially Purified Crepe

A considerable amount of experimental work has been carried out with a view to producing partially purified crepes. In the first instance the objective was a material low in non-rubber constituents to avoid discolouration of the rubber derivatives to which it was subsequently processed; in the second, low water absorption in the vulcanised state was aimed at, the rubber being required for use in electric cables.

The processes tried included digestion with enzymes and bacteria, centrifugation, soaking of coagulum, before and after machining, and coagulation at low dry rubber content. In response to consumer request four tons of the first type of material have been prepared, the process comprising coagulation of centrifuged latex diluted to a d.r.c of 5%; followed by creping and drying in the usual manner. Reports on the material are now awaited.

Work on the second type of purified crepe has been complicated by a marked tendency to oxidation of the rubber, which follows any advanced degree of purification by the processes tried. It is interesting to note that centrifugation resulted in low ash and trypsin treatment in low nitrogen content, as was to be expected. The water absorption of rubbers produced by these two processes was approximately the same. Combination of the two processes gave a somewhat lower water absorption, but the rubber rapidly became sticky and was impracticable for commercial handling. It was found that in some instances, the water absorption of the rubber was at a minimum when the d.r.c. of coagulation was between 10 and 15%. Hundredweight quantities of rubbers prepared by the different processes are now undergoing evaluation in the U.K.

Rubber-Lignin Masterbatch

Preparation—A pilot plant for producing rubber-lignin masterbatch by a continuous operation has been completed and hundredweight quantities produced. The process is satisfactory and a preliminary costing has been worked out. Further work comparing the suitability and the cost of a batch process with the continuous one has yet to be carried out.

Compounding—In view of the unusual compounding behaviour of rubber-lignin masterbatch, it was decided that the development of suitable compounding techniques should be studied at the same time as methods of preparation. It has now been

established that two types of vulcanised material can be produced from rubber-lignin masterbatch, and application has been made for patent protection of the discoveries.

The first type is a hard vulcanised material, suitable for example for shoe soling. This product is obtained when vulcanisation is carried out in the presence of a few per cent of free water. Satisfactory and reproducible products have been prepared in the laboratory by cold milling the stock with water immediately before vulcanising; the degree of hardening is roughly proportional to the amount of free water present. Similar results have been obtained working with full scale plant in a rubber factory, but the process was less reliable and much more work requires to be done on a factory scale before a satisfactory and economic technique can be established. Certain amines and phenols can be used in place of water to produce these hard products, the properties of which appear to depend upon the development of a lignin gel structure in the vulcanisate.

High temperature milling of rubber-lignin stocks removes most of the free water, and no hardening of the vulcanisate is then obtained; the products are of the second type mentioned above and are soft, showing high resilience and good tear strength. There appears to be a wide field of industrial application for exploration.

To obtain optimum properties in these soft vulcanisates, it has been found preferable to use litharge as an activator in place of zinc oxide, or to employ the lead salts of the vulcanisation accelerators. Of the accelerators investigated, cyclohexylbenzthiazylsulphanamide and lead pentamethylenedithiocarbamate have been found the most effective. Low sulphur contents, (not exceeding 2½ parts per 100 rubber) were shown to be necessary to avoid blooming. In many cases stearic acid appeared to have a detrimental effect upon cure and better results were obtained by omitting it from compounds containing organic accelerators.

Further laboratory work on the compounding of rubber-lignin masterbatch is necessary before compounds suitable for industrial use can be recommended.

Graft Polymers

Work in the B.R.P.R.A. laboratories and also in the U.S.A. has demonstrated the advantages of grafting on to the rubber molecule chains of synthetic polymers, which impart to natural rubber novel and valuable properties.

Investigations carried out in Malaya were aimed at adapting methods for graft polymer preparation to tropical conditions. so that the basic cost of production in the East could be compared with that in consuming countries.

A simple method of preparation has now been developed for rubber-methyl methacrylate grafts, which would permit easy production in most Malayan estate factories. The chief problem was that of coagulating the rubber-polymer latex, which tends to form flocs, rather than a coherent coagulum. It has now been shown that by careful control of conditions (chiefly pH and ionic strength) under which coagulation occurs, coagula are obtained which can be sheeted on a creping mill without undue trouble. Using this method grafts containing 30% and 50% methacrylate have been handled satisfactorily, batches up to 150 lb having been prepared without difficulty.

Preliminary experiments with rubber acrylic acid grafts showed that although the grafts could be prepared in the latex form, yields were low. Cumene hydroperoxide/tetraethylenepentamine was found to be a more effective catalyst that potassium per-

sulphate/bisulphite. In all preparations of rubber grafts by the methods adopted, it has not been possible to obtain a product which is 100% true graft; the true graft is always contaminated with free rubber and free polymer. It is, of course, important to analyse the product obtained on this basis and methods have been worked out at B.R.P.R.A. On the basis of such a characterisation the products prepared in Malaya were very little different from those prepared in the U.K. Technological properties of vulcanisates were also found to be much the same. Technological properties of pure graft rubbers, prepared by removal of free rubber and free polymer, have been examined in Malaya and found to possess resilience inferior to that of the impure material; the pure grafts were harder.

In the course of work in characterising rubber grafts, it was observed that a change in the properties of a simple mixture of free rubber and rubber/polymethyl methacrylate graft can be induced by dry milling. Although additional true graft does not appear to be formed, some degree of molecular entanglement or association appears to be obtained between the original graft and the added free rubber. The properties of vulcanisates prepared with the materials are influenced by this 'molecular association'. The change is inhibited by 'short stops' or radical acceptors. It is worth noting that whilst the phenomenon is quite reproducible in Malaya using freshly prepared rubber, it has been reported by B.R.P.R.A. that a similar reaction does not appear to occur in the U.K. using rubber a few months old.

Redox Hardened Rubber

It is of interest to note that the properties of latex concentrates, in which the rubber had been hardened by peroxamine treatment, showed no deterioration after one year's storage. Foam rubber was prepared from the latex without difficulty and the dry rubber was still hard. Further examination awaits the establishment of test methods for foam rubber in the laboratories.

Unvulcanised Rubber Powder

At the request of the Road Surfacing Committee of the Natural Rubber Development Board, an attempt was made to prepare an unvulcanised rubber powder. Field latex was coagulated with sulphuric acid after the addition of lime. The coagulum was passed through creping rolls and then through a hammer mill, when it disintegrated to a crumb which was talced. After drying, a further passage through the hammer mill gave a free flowing coarse powder which has shown no tendency to mass on storage. Samples have been forwarded to the U.K. for test and B.R.P.R.A. have recently reported that although the crumb imparts rubbery characteristics to bitumen quite quickly, the relatively coarse particles are slow to dissolve completely and still remain incompletely dissolved after two hours' heating at 150°C. Another type of unvulcanised rubber powder, in commercial production in Malaya, has been recommended for trial by the Road Surfacing Committee.

Experiments with powder prepared from skim latex showed it to be unsuitable for rapid solution in bitumen.

Special Crepes

A series of specially prepared crepes containing different proportions of a rubber peptising agent and an antioxidant were prepared on request and forwarded to the L.A.C. for tests.

PREPARATION AND PRESENTATION

Drying of Rubber

The experimental tunnel, constructed to obtain basic data on the drying of rubber coagulum, has been under trial and has proved very satisfactory. Minor modifications to give improved operation will probably be desirable at a later date, but meanwhile work is being carried out with the plant in its present form.

A study has been commenced of the changes occurring in coagulum immediately after formation and during machining, this work representing the initial stages of the de-watering process, which is continued and accelerated by subsequent heating in a drying shed. The work has not yet been completed, but the following observations are worth recording.

The water content of coagulum prepared and machined under standard conditions is dependent upon the pH of coagulation, increasing from 45 — 50% at pH 4 to 50 — 60% at pH 4.5. The extension of coagulum on machining is approximately equal in the width and length dimensions; the recovery due to relaxation of stress however, is greatest in the direction of machining. After machining, water is lost from coagulum by syneresis even when the sheet is under water. The rate of loss increases with increasing temperature and is also dependent upon the pH at which the coagulum was prepared. During the factory operation of 'dripping', syneresis and evaporation occur simultaneously.

The equilibrium moisture content of 'dry' sheet rubber increases steadily with relative humidity to a value of 0.5% at 75% r.h. As the relative humidity is increased further, the equilibrium moisture content rises more rapidly to a value of 2.5% at 95% r.h. The equilibrium moisture content is also influenced by the pH at which coagulation occurred.

Approaching the problem from another angle, a study has been made of the heat balance for an R.R.I. type A smokehouse, employing data already available. Experimental work is needed to confirm some of the assumptions made, but the present estimate shows that for efficient running the requirements are three to six million B.Th.Us. to dry a thousand pounds of sheet rubber.

Rubber from Centrifuge Bowls

On shutting down a centrifuge used for latex concentration small quantities of rubber are found in different parts of the machine, contaminated with varying amounts of non-rubber substances. Over a period of time considerable quantities of rubber accumulate and are disposed of in various ways, some of which may not be completely desirable. Typical samples of these fractions are being collected, and submitted to analytical and technological tests with a view to determining the best method of treatment for disposal. The results show fractions containing up to 20% ash and as little as 20% rubber hydrocarbon.

Packing of Rubber

Observations both in Malaya and in the country of destination, have been made on a commercial shipment of 80 lb bales of crepe rubber packed in paper bags. The conditions of the trial were fairly stringent, but the bales arrived in good condition. In this instance the paper bags proved to be very satisfactory, but more trials would be required before definite conclusions could be drawn.

An experimental shipment is now in hand comparing paper bags with a variety of other wrapping materials, including polythene, treated papers, etc. Present indica-

tions suggest that the cost of such forms of wrapping are justified where the cleanliness of the rubber is important, such as first quality pale crepe.

ADVISORY AND DEVELOPMENT

Shortage of staff during 1955 has had a serious effect upon our advisory and development work. Plans for the year had included the revision of many advisory publications, the issue of new ones and much closer liaison with estates and factories. Our achievements in these directions have unfortunately fallen short of our objectives, although efforts to maintain correspondence and visits to estates at the same level as before, proved more successful. It is naturally hoped that during 1956 we may be successful in recruiting staff.

Enquiries received still show latex concentrate production to be the most troublesome of producers' problems; enquiries concerning sheet and crepe were a little less than during the previous year. Office records show the following:

Subject	*Letters received*		*Letters despatched*	
	1954	*1955*	*1954*	*1955*
Sheet production	362	287	399	358
Crepe rubber production	448	397	477	423
Latex production	795	778	931	1,034
Other processes	116	89	132	165
Technical Classification of Rubber	2,392	2,153	910	610
Research & others	306	376	461	582
Total	4,419	4,080	3,310	3,172

	1954	*1955*
Visits — Advisory	169	138
Experiment Station	227	384
Research & others	26	39
Interviews	501	431
Lectures to Planters' Associations	5	2
Samples examined:		
Latex hydrometers	118	97
Customs' samples for d.r.c	782	690
Latex samples	1,546	1,421
Sodium bisulphite	24	11
Coagulants	2	Nil
Defects in sheet & crepe	201	218
T.C.R.	31,843	27,672
Others	114	94
Total	34,630	30,203

Latex & Latex Concentrate

Dry rubber content—Many of the enquiries concerning latex have been from estates selling field latex to concentrate producers, and have centred around accurate methods for determining d.r.c. A considerable number of estates have now equipped themselves with the apparatus necessary to carry out the B.S.I. method for determining d.r.c., the R.R.I. giving advice on the equipment required and demonstrating to factory assistants the method of carrying out the test.

Bacterial contamination of concentrate—Following R.R.I. advice, considerable efforts have been made by a number of factories to improve the quality of latex concentrate production. A growing awareness of the dangers of bacterial contamination has led many producers to request bacterial counts on samples of their concentrate production. This has often led to an examination of field and factory conditions, with a view to eliminating sources of bacterial infection. Modifications in procedure and the use of far more extensive and thorough cleansing have been recommended and usually put into practice with startling improvements in latex quality. A routine laboratory for determining bacterial counts on latex samples is at present being set up in the Division, to cope with the demand.

The work represents an extension and an advance on earlier work on latex contamination which employed the VFA test as a criterion. The VFA test does not indicate whether viable bacteria are present in latex, but only that contamination has occurred at some time unknown. An actual count of viable bacteria, which however takes up to four days to complete, shows the present condition of a given concentrate and thus indicates whether preservation is adequate. Whilst a bacterial count is to be preferred as a diagnostic tool, the VFA test has not been superseded, as it still continues to serve a very useful function as a preliminary and rapid means of detecting whether putrefactive deterioration has occurred in latex. Much work remains to be carried out in this field, particularly concerning the effect of transportation and storage.

The early use of preservatives in the field is still found to be the best method of ensuring good quality field latex; formaldehyde is particularly effective in reducing VFA formation.

Ladder tapping—Continuing observations of the effect of ladder tapping, it has now been found that the mechanical stability of concentrate prepared from the latex is often different from that obtained with latex from normal tapping; in some cases an increase, in others a decrease, has been noted. In the case of Tjir 1 buddings from six different areas, it was found that ladder tapping reduced the mechanical stability of concentrate to almost half the normal value.

Preservation—Preliminary work at the R.R.I. has indicated the value of three new preservative systems for use with latex, not only in the field as anti-coagulants and in the factory as short term preservatives, but also as long term preservatives for concentrate. The three sysems are: low ammonia with antibiotics, low ammonia with sulpha derivatives, and low ammonia with boric acid. Patent application has been made for all three systems, but much work requires to be carried out before the systems can be established as of commercial value.

Skim rubber—Considerable interest has been shown by latex producers in the disposal of skim latex, particularly in methods of deammoniation, and in the production of attractive looking skim sheet and light coloured skim crepe. A simple test for distinguishing skim rubber from standard R.M.A. grades has been developed.

Sheet Rubber

Defects—With the relatively high prices and increased differentials between first and lower grade rubbers obtaining during the year, there has been considerable interest in methods of avoiding defects which cause the downgrading of RSS.

The principal defects in sheet have been bubbles due to precoagulation and fermentation. It has been observed that bubble formation often correlates with the use of upper tapping cuts and intensive tapping methods. This is believed to be due to increased bacterial infection which occurs owing to the flow of latex over larger areas of bark. Evidence for this view is the presence in such latices of high proportions of gas-producing bacteria. Bubble formation can usually be prevented by the addition of 0.06% of formaldehyde on the latex. The resulting sheet may be darker, but is usually of good quality.

There is little evidence for the view sometimes expressed that the use of yield stimulants leads to bubble formation. As this practice is often resorted to in conjunction with upper cuts or other intensive tapping methods, it is believed that the association has led to the erroneous view that the yield stimulant is responsible, whereas the effect is most likely due to the use of intensive tapping.

Precoagulation—Latex from Gl 1 buddings on coastal areas in Selangor, has shown particular difficulty with regard to precoagulation. No completely satisfactory method of overcoming this tendency has yet been found, although the use of anticoagulants such as formaldehyde and boric acid have sometimes resulted in improvement. A more satisfactory way of dealing with the problem is to mix the unstable latex with equal parts of a stable one, adding formaldehyde to each coagulating tank together with the water or the acid; addition of formaldehyde to the latex bulk may cause local clotting.

Drying—Numerous enquiries have been received regarding smokehouses and it is of interest to note that R.R.I. type houses are being built almost exclusively at present. One advantage of this tunnel type smokehouse is that it can readily be adapted to air drying, an advantage on estates where shortage of firewood may necessitate the use of other means of heating, such as oil-firing.

Considerable interest has been shown in air-dried sheet, arising both from shortage of firewood and from market demands when ADS has often obtained an appreciable premium over RSS 1. Several samples of sheet partly smoked and partly air-dried have been examined, the properties usually being satisfactory. It is recommended that smoking follows air-drying, so that the maximum amount of smoke ingredients are retained by the rubber, ensuring maximum resistance to mould growth.

Crepe

Bleaching—The R.R.I. process for bleaching pale crepe continues to be used in most crepe production, apart from a few producers of total latex crepe and a very few producers of No. 1 pale crepe. Common practice is to employ only a few ounces of the bleaching agent per 1,000 lb of rubber, but in some instances as much as 30 ounces is used. Interest in the production of pale crepe fell off considerably during the early part of the year, but has revived during the last two months. Interest in sole crepe followed the same trend as that for pale crepe, but on the whole there were fewer enquiries than in past years.

Two factories have produced satisfactory brown sole crepe, in which skim rubber was mixed with the customary scrap and lump. This appears to be a satisfactory outlet for skim rubbers, which avoids infringement of R.M.A. type descriptions.

Colour of remilled crepes—Means of lightening the colour of brown crepe are continually being sought and a recent observation is worth recording. The darkening of scrap rubber is usually thought to be due to enzymic activity; it has now been shown that a high manganese content can lead to further darkening. Contrary to earlier belief, it has been observed that a very few Malayan rubbers contain a relatively high proportion of manganese. These are tree scraps, the manganese occurring in the bark of the tree and thus contaminating the scrap. Cup scrap is not affected. It should be emphasised that as far as it is known at present, trees with bark having a high manganese content are rare and have occurred only in two areas. Washing of the contaminated scrap with detergents prior to milling effects considerable reduction in the manganese content, and was observed to improve the colour of the crepe in some instances.

Colour of normal compo crepes can often be improved by treatment of the scrap with sodium bisulphite solution, which inhibits enzyme activity. Soaking with detergents sometimes effects an improvement in colour, and almost invariably leads to a reduction in dirt content. Examination of a proprietary detergent compound claimed to give a cleaner and lighter coloured crepe, showed a considerable reduction in the dirt present, but no appreciable improvement in colour.

It is of interest to note that considerable difficulty has been experienced in machining scrap from yield stimulated trees, due to contamination of the rubber with the grease used as a carrier for the hormone. More care in applying the yield stimulant and in handling the scrap resulted in normal milling behaviour.

Special and Modified Rubbers

Cyclised rubber—Cyclised rubber masterbatch has been manufactured by four producers, who have submitted samples for quality control tests representing a total of some 80 tons.

Superior processing crepe—Over twentythree tons of superior processing crepe have been manufactured at the R.R.I. Experiment Station factory in response to requests from the U.K. Commercial production by one company was undertaken towards the close of the year. Consumer interest in this type of rubber appears to be considerable, and all reports on samples so far received have been very favourable.

Purified rubbers—Four tons of a partially purified crepe have been prepared at the E.S. factory in response to an order from the U.K. It is understood that the material is required for the preparation of a rubber derivative. Hundredweight samples or more highly purified crepes have now been sent for manufacturer evaluation in reply to requests for low water absorption rubber to compete with plastics for use in cables.

Technically Classified Rubber

During 1955 an average of 115 estates have been participating in technical classification; samples tested represent about 32,000 tons, of which 29,000 tons were RSS 1. Nearly 2,000 tons of air-dried sheet were classified.

Packing houses and remillers have shown less interest in the scheme, samples tested representing approximately 3,000 and 550 tons respectively from these two sources. More than half of the packing house rubber consisted of RSS 1, with RSS 2 and 3 forming most of the remainder. Remilling production comprised of largely thin brown crepes.

Consumer demand still appears to be mainly for the middle class, or 'yellow' rubber, with little or no interest in the 'red'. A market exists for limited quantities of 'blue' rubber. It is fortunate that the conversion of 'red' into 'yellow' rubber is a comparatively simple matter for estates, and a number of factories are now employing R.R.I. methods to convert all their crop to 'yellow' rubber.

The R.R.I. has continued to act as coordinating Institute for technical aspects of the scheme under the auspices of the International Rubber Research Board.

In view of the interest shown by sister Institutes in extending technical classification to cover cleanliness as well as vulcanising characteristics, the examination of Malayan rubbers for dirt content has been continued. The present survey is not yet completed, but already indicates marked differences between R.M.A. types and considerable variation within certain types. Comparison of the dirt content of rubber from all producing territories concerned is obviously required before specification limits for any international classification scheme can be considered.

W. G. Wren
Head of Chemical Division

Smallholders' Advisory Service

Mr J. M. F. Greenwood and Mr J. W. L. Bevan were on duty throughout the year. Mr Greenwood continued to act as Smallholders' Advisory Officer until the return of Mr L. R. Davidson from home leave on 23 January. Inche Shamsuddin bin Yub Ahmad, former Rubber Instructor, having obtained the degree of Bachelor of Agriculture at Queen's University Belfast was appointed Assistant Smallholders' Advisory Officer with effect from 23 October.

An experienced Malay Rubber Instructor left the Service at the end of January to accept employment under the Rubber Industry (Replanting) Board and an Indian tendered his resignation, to be effective at the end of the year, for the same purpose. During the year three Chinese Rubber Instructors resigned to take up managerial appointments with plantation companies. A Malay with post-collegiate experience was appointed Rubber Instructor early in the year and four RRI Scholarship holders at the College of Agriculture completed their diplomas and joined the Service. There were thus 31 Rubber Instructors in the Service at the end of the year. In addition to the posting of new Rubber Instructors for training and to their first stations six transfers took place. Three Rubber Instructors were absent for three month periods of long leave during the year.

Two open scholarships were offered for the diploma course at the College of Agriculture and were awarded to a Malay and a Chinese candidate. A third scholarship was provided for a Chinese Junior Rubber Instructor who had the necessary School Certificate and had shown notable ability during a year's service. With the general improvement in the educational standards of candidates for appointment as Junior Rubber Instructor it may be possible in future to limit the award of RRI scholarships to those who have proved their suitability for advisory duties in the field.

Nine new Junior Rubber Instructors were appointed in April after a course of training. One of these resigned after a few months service and the appointment of two Junior Rubber Instructors was terminated. One Junior Rubber Instructor was at the College of Agriculture and at the end of the year the seventeen remaining on field duty were distributed as shown below:

Selangor	1	Pahang	2
N. Sembilan	1	Trengganu	2
Malacca	1	Kelantan	2
Perak	3	Kedah	3
Johore	2		

The engagement of one Rubber Demonstrator was terminated, four resigned and one new appointment was made. There were thus 20 Rubber Demonstrators in the Service at the end of the year.

Our aim in employing Junior Rubber Instructors to increase our strength in new planting areas has not been fully realised because of the importance of effective supervision of their work while they gain experience. The losses of experienced Rubber Instructors which has been noted has not been conducive to initiation of new personel.

Certainty as to Government intentions with regard to the development of new areas is another requirement for the satisfactory posting of staff. The project of resettling

population along the railway line in Ulu Kelantan has provided a clear cut case for the posting of a Junior Rubber Instructor in that area and plans are in hand for providing quarters in Dabong new village since no private accommodation can be obtained in a resettled area.

Progress in providing quarters for Rubber Instructors has been slow during the year and only on the Seremban site has building commenced.

Training for Replanting Scheme staff was provided in our course for prospective Junior Rubber Instructors and altogether 15 persons who completed the course found employment with the R. I. (R). B. Six management trainees sponsored by the Rural & Industrial Development Authority were accepted on this course as a preliminary to their period of cadetship on rubber estates. A course of instruction in Malay, lasting three weeks, was organised in September for 24 Replanting Subordinates in the employment of the R. I. (R). B.

ADVISORY

Manufacture

Sale of latex to concentrate producers remained popular with those smallholders who have this outlet for their rubber. Demand was maintained for the greater part of the year and the establishment of a new factory as purchaser for smallholders' latex in North Perak resulted in a marked increase in sales of latex in that area. Towards the end of the year there were indications that concentrate producers wished to curtail throughput and in appropriate cases smallholders' organisations were advised by Rubber Instructors to establish small factories for sheet manufacture. Records noted by Rubber Instructors of quantities of smallholders rubber processed in central factories are summarised in the following Table.

Territory	*Collected for sale as latex*	*Collected as latex & made into sheet*
	Tons	Tons
Selangor	1,482	438
N. Sembilan	711	—
Malacca	30	35
Perak	852	133
Johore	1,275	631
Pahang	—	178
Kedah/Perlis	317	—
Total	4,667	1,415

Planting of Rubber

The principal task of Rubber Instructors with regard to replanting has been demonstration of the use of 2,4,5-T as a tree poison. This material has not yet been

employed on a large scale but a steady increase in its use may be expected as information on simplicity of application and low labour requirement spreads through the kampongs.

New planting in 1955, as Table 1 indicates, shows a marked increase on the 3360 acres recorded in 1954 and this reflects the intentions of the less developed States to make land available for rubber planting. The stated intentions of several territories to encourage new planting suggest that there may be even larger acreages in the future. The importance of economy in administrative and technical effort indicates the need for planned development of new areas in large compact blocks, but the 1955 new planting has largely been done by individualists ahead of State planning. It is manifestly impossible for our organisation to record all the plantings established in outlying places and the figures in Table 1 may be taken as minima for the year. Plantings which have escaped record are likely to have been established with ordinary seedlings with little likelihood of intention to budgraft. Increased staff to provide technical information and assistance are needed if new plantings are to be completed at the standard aimed at for replantings.

Table 1. New Planting During 1955

Territory	Total new planting (acres)	New planting with clonal seedlings (acres)	Budgrafting on previous new planting (acres)
Selangor	129	91	19
N. Sembilan	792	606	284
Malacca	—	—	—
Perak	1706	1435	354
Johore	98	—	212
Pahang	2518	2330	1115
Kedah/Perlis	1076	838	318
Penang & P.W.	57	—	—
Kelantan	1139	984	381
Trengganu	535	258	50
Total	8050	6542	2733

Planting Material

1955 was the first year in which a surplus of clonal seedlings was available to smallholders as a result of an excellent seed season in 1954. Had more accurate information been available on supplies and requirements there is no doubt that authorities would have encouraged sufficient new planting to utilise all clonal seedlings not required for replanting. Shortage of supplies of clonal seed has, in fact, been considered to provide

an obstacle to new planting and if reliance is to be placed solely on this material, uncertainty will remain because those States for which new development is important have inadequate local sources of suitable seed. In Kelantan the State Agricultural Officer has accepted the continuing shortage of clonal seedlings and new development will be planned on the basis of budgrafting. We are providing additional staff to further this work.

Maintenance of Young Rubber Areas

Adherence to certain minimum standards of upkeep is ensured for smallholders' replantings by the conditions of payment of grant instalments by the R. I. (R). B. These are effective up to the age of 3½ years when the final instalment is normally paid. Thereafter the greatest danger is that replantings will be tapped before they are properly mature. We have taken part in consultations with officers of the Department of Agriculture and the Chief Replanting Officer, Fund 'B' to define conditions for the cultivation of crops between rubber tree rows. Conditions imposed relate to distances between rubber and various crops and the period during which catch-crops could be permitted.

Rubber Instructors during 1955 have drawn attention to the devastating effects of uncontrolled root disease in many replantings about three years after planting. This is in accordance with expectations; the predisposing cause of a high incidence is the practice of felling old trees leaving stumps and roots intact in the ground. Where stumps and roots are not removed it is considered desirable to poison either the standing tree or the stump. Sodium arsenite has been proved as a tree poison which can reduce the incidence of root disease in replanting. 2,4,5-T however is more readily available for use by smallholders than sodium arsenite and its effect in hastening the the death and disintegration of roots is similar. Poisoning of standing trees or stumps is therefore recommended as a first step in combating root disease whenever roots are not removed. Poisoning does not climinate the need for careful watch on young rubber areas and promptness in treating root disease when discovered. It will however reduce the amount of work.

Generally the problems of maintenance of young rubber trees are less in new plantings than replantings. This is because the naturally occuring cover plants are of a better type and more vigorous than in replantings. Much depends on the past history of the land; where soils have been degraded by shifting cultivation and lalang has become established new plantings may be as difficult to develop as replantings.

INFORMATION

In addition to provisions for training staff for ourselves, the R. I. (R). B. and R.I.D.A. we were able to arrange two training courses at the Experiment Station for young Malays. These were each of one month's duration and the seventyfour trainees attended at their own expense. The local training course for Chinese at Batu Pahat was completed in April and a second course commenced in September. A Malay course finished at Muar in May. Seventeen out of the twentythree students at Batu Pahat and twelve out of twentyfour at Muar were awarded certificates for satisfactory completion of the course. Two at Batu Pahat obtained distinction. Other training courses organised by Rubber Instructors were for schoolboys at Sungei Patani and for the rehabilitation camp at Taiping.

Budwood has been provided to establish selected clones in three further areas in Johore, Kedah and Pahang. Clones supplied were RRIM 513 and 526, PR 107 and

RRIM 603 and 612. Further single acre plots will be established with selected clones when suitable areas are available and budwood will be provided for field budding. Such areas budded with the most promising new clones may provide clone demonstrations in the future.

Our mobile cinema unit was equipped during the second half of the year and made visits to Johore, Kelantan, Trengganu, Malacca, Pahang, Kedah and Perak. Rubber Instructors arranged programmes whereby screenings of films of topical importance were given in selected kampongs. Experience has shown that where such programmes develop into general kampong entertainment the value of the instructional films is lost. In future Rubber Instructors will arrange the films for selected audiences who have a real interest in particular subjects and have received preliminary training and demonstration.

Mr Greenwood has collaborated with officers of the Pathological Division and Photographic Section in photographing material for films on control of root diseases in rubber. He will undertake the editing of a film on the subject for smallholders during the early part of 1956. Exhibits were provided for State and Settlement Agricultural Shows in Pahang, Negri Sembilan, Province Wellesley and Johore, and for several District shows in the same States and in Malacca, Selangor and Perak. The mobile cinema unit attended some of these shows and screened films to elaborate on the subject matter of the exhibits. The RRI smallholders films were also used in conjunction with the exhibit provided by the Botanical, Soils and Pathological Divisions for the Malayan Agri-Horticultural Association's Show in Kuala Lumpur in August. Rubber Instructors were on duty throughout the show to explain the exhibit to smallholders.

Mr Wong Mun Yun provided an article on tree poisoning with 2,4,5-T for the Negri Sembilan Agricultural Department's December news letter.

The English edition of 'Replanting on Smallholdings' was received in October and the Chinese and Jawi editions were with the printer at the end of the year.

INVESTIGATIONS

INVESTIGATIONS OF PLANTING AND REPLANTING METHODS APPLICABLE TO SMALLHOLDING CONDITIONS

The replanting trials established in 1948, 1949 and 1950 on the R.R.I. smallholding at Ampang were developed as originally planned to provide information on the possibilities of hedge planting with progressive removal of the old stand. Old trees in the 1948 and 1949 plantings remained at 25% of the original stand throughout the year. In the 1950 section in which the old trees were originally pollarded a reduction of the old stand to 50% of the original was effected by poisoning non-yielding trees. Thinning of 25% of the replanted stand was done in the 1948 and 1949 replants.

Average girths at 60 inches for samples of trees in these plantings at December 1954 and December 1955 are noted below:

	December 1954 (Inches)	*December 1955 (Inches)*	*Increment (Inches)*
1948 double rows 3ft x 4ft at 64ft	9.0	10.8	1.8
1948 double rows 4ft x 4ft at 64ft	10.6	12.9	2.3
1949 double rows 5ft x 6ft at 64ft	8.0	9.7	1.7
1950 4ft x 54ft	9.2	12.0	2.8

The opportunity of thinning amongst closely planted trees in hedges was utilised to test the possible hazard of 2,4,5-T as a poison in thinning. Out of a total of 475 trees in this hedge planting, ninetyone were poisoned in April by applying 5% 2,4,5-T to a six inch band at the base of each tree. Only three of the unpoisoned trees showed some slight signs of abnormal leaf fall. These had recovered by the end of the year and there is no certainty that 2,4,5-T had any connection with the condition. In a budwood nursery however an untreated plant died after three plants at distances of approximately three feet from it were poisoned with 2,4,5-T. Many other plants were unaffected though equally close to treated plants and the possibility of accidental contact with poison when treating the nearby trees cannot be excluded.

INVESTIGATION OF COSTS OF REPLANTING BY SMALLHOLDERS

Data concerning cost of replanting was recorded from ten replantings carried out in 1954 and further information on maintenance procedures and costs was obtained where possible in 1955. As a result of occurances common on smallholdings such as change of ownership, absence of the owner, or loss of interest in the work we have not been able to collect detailed information on which full reliance can be placed. The data is insufficient for detailed analysis and the study provides merely a general indication of the range of costs for certain items in replanting on smallholdings. Experience gained will assist in any future study of this nature.

INVESTIGATION OF PROCESSING AND MARKETING OF SMALLHOLDERS' RUBBER

Mr Bevan has utilised a sample, established by the Department of Statistics for securing routine information from rubber dealers on purchase of rubber from smallholders, to investigate the market structure for smallholders' sheet rubber at the 'first buyer level'. It would have been desirable, to complete the information on this subject, to have undertaken a physical check on moisture content and grade of rubber purchased. In the time available, however, it proved impossible to devise a practicable sampling technique which would provide a measurement of grade and moisture content linked with price paid.

In this study of marketing Mr Bevan's attention was directed to a system of processing which has been adopted by Chinese, in some instances over many years. This is the practice whereby an individual makes available to neighbouring smallholders and their tappers, the facilities required to process sheet rubber and charges a fixed amount per unit of rubber processed.

The typical central processing centre of this type is a spacious shed with a sound, well drained concrete floor. A good water supply is made easily available for workers in large, low concrete tanks. Benches for coagulating pans, sieves and large hand mangles are provided by the proprietor but coagulating pans are commonly the property of smallholders. The proprietor may stock formic acid for purchase and use by smallholders. He generally has a smoke house and store which smallholders may use. Smallholders identify their own sheet by the use of an individual metal stencil which is passed through the marker roller with each sheet.

During December Rubber Instructors reported on 124 centres of this type located in Selangor (56), Pahang (31), Perak (27), Negri Sembilan (9) and Johore (1). These centres were used by over 6,500 smallholders of whom 88% were Chinese. The acreage served totalled approximately 33,500 acres and the daily throughput was more than 60,000 lb of rubber. Rubber from such factories has not been included in the figures recorded in the Table on page 69.

The grades of rubber produced in these organisations compare very favourably with estimates which have been made of grades of all smallholders' rubber exported from the country. On an average about 80% of the rubber produced in the centres investigated is Grade 2 or better whereas for total smallholders' production the estimate is 26%*.

The capital cost of these central processing organisations is low and the buildings and equipment of the 124 cases investigated were valued at, and had been established for less than $850,000 giving a cost of approximately $14,000 for facilities to process 1,000 lbs of smoked sheet per day. Charges for processing, including smoking, range from 2½ to 8 cents per katty with the majority under 6 cents per katty or 4½ cents per lb. Sixtysix of the factories or approximately 53% have been established since the beginning 1950 indicating that resettlement and emergency restrictions have tended to promote this form of centralisation. In view of the low capital requirement, economy in production and improved quality of product there appear to be good grounds for official encouragement of this system of processing sheet rubber. The possibility of extension in predominantly Malay areas merits special study.

L. R. Davidson
Smallholders' Advisory Officer

*Research archives of the Rubber Research Institute of Malaya (RRIM Document VII).

SENIOR STAFF AND GRADUATE ASSISTANTS

ADMINISTRATION

C. E. T. Mann, M.Sc., F.I.R.I. *Director.* On leave 1 June. (First appointed 15 June 1927)

C. G. Akhurst, B.Sc., A.R.C.S., A.I.C.T.A. *Deputy Director.* (First appointed 7 October 1930)

H. S. Blacklin. *Secretary.* (First appointed 1 March 1932)

J. C. Reeves, F.C.C.S. *Assistant Secretary.* (First appointed 1 September 1950)

J. A. Faulkner. *Maintenance Engineer.* (First appointed 1 November)

PUBLICATIONS SECTION

D. R. Rexworthy, B.Sc., F.R.I.C. *Publications and Information Officer.* (First appointed 23 July 1952)

STATISTICS SECTION

D. R. Westgarth, M.Sc. *Statistician.* (First appointed 3 August 1950)

Fong Chu Chai, B.Sc. *Assistant Statistician.* (First appointed 8 July 1949)

D. K. Dutta Ray, M.A. *Assistant Statistician.* Resigned with effect from 14 June (First appointed 22 May 1952)

G. Chidambara Iyer, M.Sc. *Assistant Statistician.* (First appointed 20 August)

EXPERIMENT STATION

R. F. Harley, M.C., A.I.S.P. *Manager.* On leave until 15 April. (First appointed 27 August 1937)

A. E. Browne, M.C. *Assistant Manager.* On leave from 1 August. (First appointed 1 February 1948)

J. E. Ellison, *Assistant.* (First appointed 10 July 1951)

J. D. Macritchie, B.Sc. (Agri.) *Assistant.* (First appointed 15 December 1954)

J. H. Chapman, B.Sc. (Agric.) *Assistant.* (First appointed 19 August)

SOILS DIVISION

G. Owen, M.Sc. *Head of Division.* (First appointed 5 January 1939)

E. W. Bolle-Jones, M.Sc., Ph.D., M.I.Biol. *Plant Physiologist.* On leave from 22 April to 17 November. (First appointed 20 August 1952)

G. M. F. Grundy, B.Sc. *Soils Chemist.* (First appointed 5 January 1953)

G. A. Watson Ph.D., A.R.C.S., A.R.I.C., D.I.C. *Soils Chemist.* (First appointed 17 November)

V. R. Mallikarjuneswara, B.Sc., M.Sc. *Assistant Soils Chemist.* (First appointed 4 April)

M. M. Guha, B.Sc., Assoc. I.A.R.I. *Assistant Soils Chemist.* (First appointed 20 May)

BOTANICAL DIVISION

E. D. C. Baptist, M.Sc., Ph.D., A.R.C.S., D.I.C. *Head of Division.* On leave 2 June until 15 December. (First appointed 20 March 1935)
C. W. Brookson, B.Sc. *Botanist.* (First appointed 23 August 1949)
P. de Jonge, Agric. Ir. *Botanist.* Sick leave in the Netherlands 11 September until 22 October. (First appointed 29 December 1950)
J. S. Lowe, Ph.D. *Plant Physiologist.* (First appointed 11 February 1953)
P. R. Wycherley, Ph.D. *Botanist.* (First appointed 26 January 1953)
J. M. Ross, B.Sc. *Botanist.* (First appointed 5 December)
T. V. Vaidyanathan, B.Agric. *Assistant Botanist.* (First appointed 1 May 1935)
V. K. Bhaskaran Nair, M.Sc. *Assistant Botanist.* (First appointed 26 May 1952)

PATHOLOGICAL DIVISION

A. Newsam, Ph.D. *Head of Division.* On leave 14 March until 16 December. (First appointed 5 April 1947)
F. W. Hutchison, N.D.A., C.D.A. *Field Research Officer.* (First appointed 5 March 1948)
R. N. Hilton, M.A. *Pathologist.* (First appointed 7 September 1948)
K. P. John, B.A. *Assistant Pathologist.* (First appointed 16 November 1936)
R. A. Fox, B.Sc., B.Agr. *Microbiologist.* (First appointed 2 March 1954)
B. Sripathi Rao, B.Sc., M.A. *Assistant Entomologist.* Attended one year course at Long Ashton Research Station from 27 August. (First appointed 6 June 1952)

CHEMICAL DIVISION

W. G. Wren, B.Sc., A.R.C.S., D.I.C., A.I.R.I. *Head of Division.* (First appointed 7 January 1950)
G. W. Drake, B.Sc., M.A. *Chemist.* On leave until 20 April. (First appointed 8 March 1948)
W. A. Southorn, Ph.D., A.R.I.C. *Chemist.* (First appointed 18 November 1952)
J. E. Morris, B.Sc. *Chemist.* (First appointed 20 June 1952)
R. F. J. Freeman, Ph.D. *Chemist* seconded from The British Rubber Producers' Research Association until 5 May. (First appointed 1 May 1952)
D. H. Taysum, M.Sc., D.I.C. *Microbiologist.* (First appointed 13 September 1954)
G. F. J. Moir, B.Sc. *Biochemist.* (First appointed 2 February)
R. S. Gale, B.Sc., A.C.G.I., A.M.I. Chem. E. *Chemical Engineer.* On leave from 27 January until 12 October. (First appointed 2 May 1951)
D. J. Graham, A.S.T.C. *Chemical Engineer.* (First appointed 31 March 1953)
L. L. Best, M.Sc., A.K.S. *Technologist.* (First appointed 7 March 1952). Resigned 4 March.
H. M. Edmondson, B.Sc. *Technologist.* (First appointed 28 August 1950)
P. F. Maher, B.Sc. *Technologist.* (First appointed 19 June 1953). Resigned 19 October.
K. C. Sekar, B.A., A.I.R.I. *Assistant Chemist.* (First appointed 1 October 1928)
R. C. H. Hsia, B.Sc. *Assistant Chemist.* (First appointed 2 January 1953)

B. C. Sekhar, M.S., A.R.I.C. *Assistant Chemist.* On leave from 4 September. (First appointed 15 September 1949)

S. J. Tata, B.Sc. *Assistant Chemist.* (First appointed 14 December 1953)

ST. Sethu, B.E.(Chem) *Assistant Chemical Engineer.* (First appointed 1 September)

SMALLHOLDERS' ADVISORY SERVICE

L. R. Davidson, B.Sc. (Agric.) *Smallholders' Advisory Officer.* On leave until 23 January. (First appointed 1 December 1940)

J. M. F. Greenwood B.Sc. (Agric.) *Assistant Smallholders' Advisory Officer.* (First appointed 25 November 1948)

J. W. L. Bevan, B.Sc. (Agric.) *Assistant Smallholders' Advisory Officer.* (First appointed 12 November 1952)

Shamsuddin bin Yub Ahmad, B.Agric. *Assistant Smallholders' Advisory Officer.* (Assumed duty 24 October)

LIABILITIES				As at 31.12.54
		$ c	$ c	$
SUNDRY CREDITORS				
Staff		39,618.65		
Merchants		115,439.91		
Miscellaneous		10,090.75	165,149.31	223,780
STAFF CONTINGENCY RESERVE FUND				
As at 31 December, 1954			330,000.00	330,000
RESERVE FOR GRATUITIES FOR EQUALISATION OF PROVIDENT FUND CONTRIBUTIONS		19,331.12		16,792
Less Investment of this reserve in the Post Office Savings Bank		19,331.12	—	16,792
EXCESS OF ASSETS OVER LIABILITIES				—
As at 31 December, 1954		4,209,635.97		
Less Refund to Malayan Rubber Fund		161,406.51		
		4,048,229.46		
Less Expenditure written off:—				
Wickham Road & Ridley Close	$461,531.65			
Ampang Road Laboratories	150,128.49			
Sungei Buloh Laboratories & Houses	810,357.95			
Rubber Powder Plant & Machinery	24,770.03	1,446,788.12		
Add Grant for Capital Works 1955		2,601,441.34		
		95,000.00		
		2,696,441.34		
Add Excess of Income over Expenditure for the year:—				
Head Office	$546,928.86			
Experiment Station	492,955.91	1,039,884.77	3,736,326.11	4,209,636
Carried forward			4,231,475.42	4,763,416

ASSETS

LAND AND BUILDINGS	$ c	$ c	As at 31.12.54 $
2¼ Mile Compound			
Land as at 31 December 1954	15,784.35		15,786
198 and 200 Ampang Road:			
At nominal value	2.00	15,786.35	
3rd Mile Compound			
Land as at 31 December 1954	31,440.35		
251, 253, 255, 257, 259 and 261 Ampang Road:			
At nominal value	6.00	31,446.35	31,446
3¼ Mile Compound			
Land as at 31 December 1954	27,582.50		
262, 264, 266, 268 and 270 Ampang Road:			
At nominal value	5.00	27,587.50	27,588
4th Mile Compound			
Land as at 31 December 1954	2,000.00		
73, 4th Mile Ampang Road:			
At nominal value	1.00	2,001.00	2,001
Eaton Road Compound			
Land as at 31 December 1954	17,147.08		
1, 3, 5 and 7 Eaton Road:			
At nominal value	4.00	17,151.08	17,151
Wickham Road & Ridley Close			
Land as at 31 December 1954	43,623.50		
Nine Bungalows,:			
As at 31 December 1954 $461,540.65			
Less			
Written off against excess of assets over liabilities 461,531.65	9.00	43,632.50	505,164
Ulu Klang			
Land as at 31 December 1954	7,705.00		
Workmen's Quarters:			
At nominal value	1.00	7,706.00	7,706
Ampang Road Laboratories			
Land as at 31 December 1954	19,526.00		
Buildings — As at 31 December 1954 150,129.49			
Less			
Written off against excess of assets over liabilities 150,128.49			
	1.00		
Additions during year 13,742.93	13,743.93	33,269.93	169,656
Carried forward		178,580.71	776,498

		As at 31.12.54
	$ c	$
Brought forward	4,231,475.42	4,763,416
Carried forward	4,231,475.42	4,763,416

			As at 31.12.54
		$ c	$
	Brought forward	178,580.71	776,498
LAND & BUILDINGS (Contd)			
Sungei Buloh			
Laboratories & Houses			
As at 31 December 1954	810,382.95		
Less Written off against excess of assets over liabilities	810,357.95		
Balance At nominal value:			
Laboratories	1.00		
Houses	24.00	25.00	810,383
Land & Quarters for Rubber Instructors			
As at 31 December 1954	4,697.76		
Additions during year	14,148.96	18,846.72	4,698
PLANT & MACHINERY At nominal value		1.00	1
RUBBER POWDER PLANT & MACHINERY			
As at 31 December 1954	24,770.03		
Less Written off against excess of assets over liabilities	24,770.03	—	24,770
FURNITURE			
Residential Houses,			
Kuala Lumpur			
At nominal value		1.00	1
Sungei Buloh			
At nominal value		1.00	1
Offices, Kuala Lumpur			
At nominal value		1.00	1
Library			
At nominal value		1.00	1
Laboratories			
At nominal value			
Kuala Lumpur	1.00		1
Sungei Buloh	1.00	2.00	1
APPARATUS & GLASSWARE At nominal value		1.00	1
MOTOR VEHICLES. At nominal value		1.00	1
WORKSHOPS At nominal value		1.00	1
LIBRARY BOOKS & PERIODICALS At nominal value		1.00	1
EXPERIMENT STATION DEVELOPMENT			
As at 31 December 1954	1,769,813.36		
Additions during year	284,319.60	2,054,132.96	1,769,813
	Carried forward	2,251,596.39	3,386,173

		As at 31.12.54
	$ c	$
Brought forward	4,231,475.42	4,763,416

REPORT OF THE AUDITORS TO THE BOARD OF THE RUBBER RESEARCH INSTITUTE OF MALAYA

We have examined the above Balance Sheet dated 31 December 1955 with the books and vouchers of the Rubber Research Institute of Malaya and report that we have obtained all the information and explanations we have required.

In our opinion, such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institute's affairs according to the best of our information and the explanations given to us and as shown by the books of the Institute.

Sgd Peat, Marwick, Mitchell & Co.
Chartered Accountants
Auditors

Kuala Lumpur
12 March 1956

$4,231,475.42	$4,763,416

				As at 31.12.54
			$ c	$
	Brought forward		2,251,596.39	3,386,173
STOCKS				
Petrol, Oil & Chemicals				
Head Office	399.93			
Experiment Station	1,690.22	2,090.15		
Empty Containers & Drums				
Head Office	1,118.00			
Experiment Station	2,595.00	3,713.00		
Stationery				
Head Office		6,570.46		
Sundry Materials				
Head Office	8,375.29			
Experiment Station	21,947.85	30,323.14		
Rubber				
Experiment Station		35,634.76	78,331.51	54,662
SUNDRY DEPOSITS			170.00	170
SUNDRY DEBTORS				
Staff				
Loans for Motor Vehicle Purchase	180,161.62			
Travelling & Sundries	44,590.40	224,752.02		
General				
Head Office	99,906.29			
Experiment Station	7,618.19	107,524.48		
Interest Accrued on Investments		6,315.86		
Payments in Advance				
Head Office	13,207.18			
Experiment Station	6,014.83	19,222.01	357,814.37	318,047
LOCAL AND BRITISH GOVERNMENT SECURITIES (Held for account of Staff Contingency Reserve Fund)				
$ 15,000 4½% Singapore Municipal Debenture Stock 1930-70/80 ($17,537*) ($15,076†)			15,000.00	15,000
$ 40,000 3% F.M.S. Government War Loan 1940-52/59 ($40,000*) ($38,402†)			40,000.00	40,000
$160,000 3% Malayan Union Government Loan 1946- 62/66 ($160,000*) ($136,996†)			160,000.00	160,000
£ 20,600 3½% British War Loan 1952 purchased during the year ($145,322*) ($135,453†)			145,322.05	—
* Original Cost — $362,859 † Market value as at 31 December 1955 — $325,927				
CASH AT BANK AND IN HAND				
At Bank				
Fixed Deposit		500,000.00		
Current Account		680,718.97		
		1,180,718.97		
In Hand		2,522.13	1,183,241.10	789,364
			$4,231,475.42	$4,763,416

EXPENDITURE

	$ c
To	
International Rubber Research Board/International Rubber Development Committee	6,103.08
London Advisory Committee	21,648.09
Board Meetings	4,048.82
Salaries of Staff on Agreement	465,299.47
Salaries of Staff not on Agreement	855,372.06
Provident Fund	139,247.55
Medical	18,368.51
Travelling	70,383.81
Emergency Expenditure	5.00
Office General Charges	34,609.86
Rent, Rates & Taxes	13,056.90
Insurance	24,188.69
Laboratory General Charges	6,095.40
Buildings & Grounds	48,125.94
Furniture & Office Equipment	20,820.15
Fixtures & Fittings	11,578.45
Plant & Machinery	14,009.62
Power, Light & Water	56,184.39
Vehicles	11,327.24
Workshop	8,123.61
Apparatus & Glassware	78,901.59
Laboratory Chemicals	22,382.44
Publications	18,373.25
Library (Books & Periodicals)	11,881.26
Exhibitions	3,806.90
Smallholders' Advisory Service	613,177.54
Field & Factory Experiments	65,589.21
Technical Classification	26,813.77
Tapping Experiments	3,217.10
Gratuities to Staff	26,336.00
Leave Pay	132,281.66
Passages	51,529.54
Grants towards Passages	890.00
	2,883,776.90
Excess of Income over Expenditure for the year	546,928.86
	3,430,705.76

Income & Expenditure Account for Experi

EXPENDITURE

To	
Revenue Expenditure	622,127.64
Excess of Income over Expenditure	492,955.91
	1,115,083.55

on) for the year ended 31 December 1955

INCOME

By		$ c	$ c
	Contributions received from the Malayan Rubber Fund	3,451,426.00	
	Less Grant for Capital Works	95,000.00	3,356,426.00
	Publications sold		7,613.96
	Rents on Houses		21,245.41
	Interest on Loans		2,768.58
	Interest on Investments		13,332.90
	Miscellaneous		29,318.91
			3,430,705.76

on for year ended 31 December 1955

INCOME

By			
	Sales & Stock of Rubber		1,041,052.05
	Sales of Planting Materials		21,566.71
	Miscellaneous		162.57
	Rubber Industry (Replanting) Board Refund on account of Replanting Cesses:—		
	Schedule II Final for 1951, 1952 and 1953	9,145.35	
	Schedule IV Final for 1952 and 1953	1,596.39	
	Schedule IV 1 October 1954 to 30 September 1955	41,560.48	52,302.22
			1,115,083.55

RUBBER RESEARCH INSTITUTE OF MALAYA
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